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LECTURES.

Friday, January 21st, 1859.

Colonel the Hon. JAMES LINDSAY in the Chair.

AN ACCOUNT of some EXPERIMENTS elucidating the THEORY on which the AUTHOR founds his PATENTED METHOD of MANUFACTURING CANNON; also of the ENDURANCE of some GUNS and other CYLINDERS made to TEST the PRACTICAL VALUE of this METHOD.

By Captain Blakely, R.A., M.R.I.A., F.R.G.S., &c.

When, last year, I had the honour of advocating before this Institution a new method of constructing cannon, I made use of arguments based on the rudimental principles of geometry to prove the great waste of materials by the present system of manufacture. I argued—

1st. That any tube pressed on from within must stretch.

2ndly. That in stretching it must become thinner.

3rdly. That, the sides of the tube becoming thinner, the outer parts, particularly of a thick tube like a gun, must be less stretched, therefore less strained, than the inner; because, to permit of their being as much stretched, the sides would have to become absolutely thicker and the mass of material greater than at first.

4thly. That a tube in which the outer parts are less strained than the inner must be weaker than if all could be equally strained.

As this line of argument proved ineffectual in convincing any of the persons charged by Government* to provide this country with cannon, thousands of the largest calibre of which have been cast within the last year, I felt great satisfaction in finding, a few weeks ago, an account of a series of experiments which completely corroborate the view I attempted, with so little success, to inculcate.

These experiments were made by Major Wade, of the U.S. Ordnance, for his government, which has been so liberal as to publish them, together with many other most interesting and valuable researches, in a book entitled "Reports of Experiments on Metals for Cannon." I will mention such of them as throw light upon the four proportions which form the heads of my argument.

Proposition 1.

A tube pressed on from within stretches.

In 1846 Major Wade, when testing some muskets by hydrostatic pressure, found the elasticity of sound barrels such, that a column of water in them, 21 inches high, could be diminished half an inch by a pressure of 2,000 lbs. A column of water 39 or 40 inches high he shortened $\frac{7}{8}$ of an inch with a pressure of 2,400 lbs. When the pressure was removed the water recovered its original height nearly.

This result cannot have been owing to the compression of the water, which would have been imperceptible with such a slight pressure; the musket barrels, therefore, must have increased in diameter during the strain: *q. e. d.*

In 1851 Major Wade measured the change in size of some hollow cast-iron cylinders, when strained from within by hydrostatic pressure. Not only were they all enlarged during the continuance of the pressure, but *in every case an addition of pressure produced an increase of diameter.* The second column of the accompanying table gives the actual measurements by Major Wade of the diameters of these cylinders when strained by the force mentioned in the first column. The uniformity of the result in such a number of cases is nearly conclusive.

Proposition 2.

A tube when stretched must become thinner.

The column in this table headed "thickness of metal" was calculated by me from Major Wade's data, the size of the inner and outer diameter. We here find that each increase of strain diminished the thickness of the tube: *q. e. d.*

Proposition 3.

The outer portions of a tube are less stretched by pressure from within than the inner portions, and the greater the thickness of the tube the greater is the difference.

The table of Major Wade's experiments proves that in No. 1 cylinder, where the sides were less than one-third of a calibre in thickness, the

EXTENSION OF HOLLOW CYLINDERS.

CYLINDER No. 1.

Force applied.	Diameters in Inches.		Ratio of Increment to the original Diameters.		Outside less stretched than Inside.	Thickness of Metal.	Area of Cross Section.
	Interior.	Exterior.	Interior.	Exterior.			
lbs.							Sq. Inches.
0,000	·8050	1·3090	One in	One in	As one to	·2520	·83681
1,000	·8061	1·3093	732	4,367	$5\frac{4}{10}$	·2516	·83603
2,000	·8083	1·3100	277	1,309	$4\frac{3}{4}$	·25085	·83468
3,000	·8102	1·3110	155	655	$4\frac{1}{4}$	·25040	·83432
4,000	·8114	1·3120	126	437	$3\frac{1}{2}$	·25030	·83486
5,000	·8126	1·3130	107	327	$3\frac{1}{16}$	·25020	·83439
6,000	·8141	1·3140	88	262	3	·24995	·83554
7,000	·8153	1·3150	78	218	$2\frac{8}{10}$	·24985	·83607
					Average $3\frac{1}{2}$		

CYLINDER No. 2.

0,000	·8030	1·812	. .	. .	. .	·5045	2·0723
5,000	·8030	1·812	. .	. .	. .	·5045	2·0723
8,000	·8053	1·813	349	1,812	$5\frac{1}{5}$	·50385	2·0722
10,000	·8067	1·814	217	906	$4\frac{1}{5}$	·50365	2·0733
12,000	·8085	1·815	146	604	$4\frac{1}{7}$	·50325	2·0739
14,000	·8110	1·816	100	453	$4\frac{1}{2}$	·50250	2·0736
					Average $4\frac{1}{2}$		

CYLINDER No. 3.

0,000	·8100	1·8120	. .	. .	. .	·50100	2·0635
5,000	·8100	1·8120	. .	. .	. .	·50100	2·0635
8,000	·8124	1·8127	337	2,588	$7\frac{2}{3}$	·50015	2·0624
10,000	·8137	1·8130	219	1,812	$8\frac{1}{4}$	·49965	2·0616
12,000	·8151	1·8134	159	1,294	$8\frac{1}{7}$	·49915	2·0609
14,000	·8171	1·8140	114	906	8	·49845	2·0600
					Average 8		

CYLINDER No. 4.

0,000	·8070	1·811	. .	. .	. .	·50200	2·0644
5,000	·8124	1·812	149	1,811	$12\frac{1}{7}$	·49980	2·0604
8,000	·8166	1·814	84	604	$7\frac{1}{5}$	·49870	2·0606
10,000	·8177	1·814	75	604	8	·49815	2·0593
12,000	·8205	1·815	59	453	$7\frac{2}{3}$	·49725	2·0585
14,000	·8211	1·815	57	443	$7\frac{3}{4}$	·49695	2·0578
					Average $8\frac{1}{2}$		

outer diameter was increased on an average $3\frac{1}{2}$ times less than the inner; and that in cylinders 2, 3, and 4, where the metal was $\frac{5}{8}$ of a calibre thick, the outside was stretched on an average seven times less than the inside: *q. e. d.*

PROPOSITION 4.

A tube in which the inner parts are more strained by pressure from within than the outer must be weaker than if all could be equally strained.

In October, 1844, Major Wade burst two 18-pounder cast-iron guns by hydrostatic pressure to find their strength. He afterwards carefully tested the strength of the metal to resist a direct tensile strain. One of these guns burst with a pressure of 9,000 lbs. per inch of resisting metal, yet a sample bar of the gun showed a strength of 27,350 lbs. per inch. The other burst with a strain of 6,082 lbs. per inch, whereas the sample showed a tensile force of 22,204 lbs. Here we have proof that some part of the metal did not exert its strength, and that in each of these guns at least the useless part amounted to the great proportion of more than two-thirds of the whole.

In his report to the Colonel of Ordnance at Washington Major Wade wrote on the subject as follows:—

"The relation between the force applied in producing a fracture in cast iron by a tensile strain in the axis of the specimen, and by that of hydrostatic pressure within the bore, appears to be somewhat greater than as three to one."

Another experiment made by Major Wade a few weeks later showed that it is the outside parts of cylinders which do not exert their strength.

He turned down the outside of a 6-pounder cast-iron gun in a lathe to such an extent as to form, from the breech near to the trunnions, a cylinder of the uniform thickness of one calibre, that is to say, with a thickness of metal on every side equal to the diameter of the bore. He cut off the trunnions, and turned a second cylindrical portion in the middle of the gun with a thickness of half a calibre. In front he formed a third cylinder with metal only one quarter of a calibre thick.

With a hydrostatic pressure of 12,400 lbs. per square inch, the thin part burst in four fissures. The piston was then inserted in the middle part where the metal was half a calibre thick, and a pressure of 20,000 lbs. burst it in three fissures, one of which extended 16 inches into the thick cylinder. In his report Major Wade wrote as follows :—

"It appears from these results, that the power of resisting in cylinders of the same quality of iron, and of the same diameters of bore, but of different thickness, varies as the thickness, but in a less ratio. Hence the increase or the diminution of the thickness of iron in a gun does not increase or diminish the strength in like proportion. The results obtained in former trials by water-pressure with those now obtained from the 6-pounder gun are all given in the following table :—

Kind of Iron.	By testing Instrument.	By water pressure per square Inch.		Thickness of Iron in parts of radius of bore.	Ratio of resistance by water pressure, the tensile strength being the unit = 1·000.
	Tensile strength per square Inch.	Within the bore.	On the area of fracture.		
18-pounder No. 1	27,350	9,000	9,000	1·000	0·329
18-pounder No. 2	22,204	9,860	6,082	1·621	0·273
6-pounder . .	33,226	12,400	24,800	0·500	0·742
		20,000	20,000	1·000	0·602

Here we see that the 6-pounder, where only one-fourth of a calibre thick, required a pressure of 12,400 lbs. per inch of bore to burst it; but that with double the thickness of metal, an addition of only 7,600 lbs. pressure, or about five-eighths of the former, sufficed to destroy it. The second equal thickness of metal, then, only exerted five-eighths as much power as the inner, the total strength being less than if they had been equally strained.

But the strength of the thinnest part was only in this experiment three-quarters (0·742) so much as if the whole of it even had been equally strained; the strength of the medium thickness therefore was only six-tenths, little more than half so much as if it had all been strained as much as the inside of all: *q. e. d.*

Although these experiments would by themselves be insufficient to establish a theory, and although I was unable by reasoning, founded on pure science, to convince many persons of the soundness of my views, still I trust that the mutual corroboration of argument and experiment will have greater effect. Here, in England, an opinion is expressed, that for certain reasons, cylinders if strained would stretch, and stretch more inside than outside; in America a number cylinders are measured during strain, and without exception all do stretch with every increase of strain, and all do stretch more inside than outside. This certainly makes it appear probable that the reasoning on which the opinion is founded is correct, and that all cylinders would follow this law.

In the case of iron tubes, an experiment which any one can make is decisive as to the stretching. A leaden ring fitted on such a tube will stretch with it when strained, but will remain enlarged when the iron is permitted to regain its original size. Mr. Greener of Birmingham made a series of experiments with the barrel of a fowling-piece, having leaden rings at intervals on it, for the purpose of showing how much each part was enlarged during the discharge of the piece. Where he found this enlargement less than at other parts he concluded that the barrel was stronger than necessary, and modelled the next he made accordingly.

The enlargement of tubes when pressed on from within, being thus proved beyond the possibility of doubt, the simultaneous diminution in the thickness of their sides will be readily admitted. No person could

expect a ring which fitted a little finger to be enlarged to fit a first finger without becoming thinner. Now any thick cylinder or tube may be considered as composed of several concentric smaller ones; and it is evident that each of these, by becoming thinner when stretched, loses some of its power of pressing the one above it. As an example, let us imagine a thick cylinder (see fig. 1.) as composed of two concentric cylinders, accurately fitting, of which the inner one is exactly like No. 3 in Major Wade's experiment (see p. 3) ·8100 inch bore, and 1·8120 inch in outer diameter, the latter being also the measure of the inner diameter of the outer tube. Now, referring to the table of the experiments (see p. 3), we find that on applying pressure from within, until the inner diameter, A B, stretches from ·8100 to ·8124 inches, 1 in 337, the outer diameter of the inner cylinder, C D, would, if quite unopposed, only stretch from 1·8120 to 1·8127 inches, or 1 in 2588. But we now imagine over this tube another, which must resist its expansion; C D would therefore stretch less. To avoid theory, let us adhere, however, to Major Wade's figures, and say that C D would not stretch more than 1 in 2588, nearly eight times less than the inside. Evidently the inside of the outer cylinder would continue to touch the other, and must therefore stretch exactly as much; that is, 1 in 2588, A B, the inside, stretching 1 in 337. If the outer cylinder be of the same proportions as the inner, and of the same metal, we may fairly conclude that E F, its outer diameter, would stretch as much less than C D as C D stretched less than A B. This would only be 1 in 19,973, or sixty times less than A B.

The whole of our outer cylinder, therefore, could be very little strained when the inside was stretched 1 in 337. To stretch the inside more would endanger its soundness, and, however much we strain it, the outer cylinder will remain about eight times less strained, that is to say, will exert eight times less power than it. Major Wade found the result the same, whether he applied a small or a great pressure. When he stretched the inner diameter 1 in 114, which must have approached the point of rupture, the outside still only yielded 1 in 906.

The outer parts of a thick cylinder are almost precisely in the same condition of uselessness as if they formed a separate tube, fitted with perfect accuracy over an inner one; and the stretching of C D, the diameter of the middle part, will be as little in proportion to that of the inside, if the division of which it is the diameter is imaginary, as if it were real.

It is evident that if we could make the outer cylinder stretch as much with any given pressure as the inner, instead of eight times less, we should get eight times as much effective strength from it. This is easily done: *we have but to form the thick cylinder of two or more concentric ones; but, instead of making them so as to fit accurately, each must be slightly too small to go over the one underneath it without force.*

If, for example, over the inner cylinder we have been considering, whose outer diameter is 1·8120, we place another whose inner diameter is only 1·8074, or about $\frac{1}{200}$ of an inch less (see fig. 2), then, when pressure from within enlarges the whole to such an extent that A B, the inner diameter of the inner tube, is stretched 1 in 337, and C D, its outer diameter, 1 in 2,588, or from 1·8120 to 1·8127 (see table, page 3), the inner diameter of the outer cylinder will not, of course, be stretched

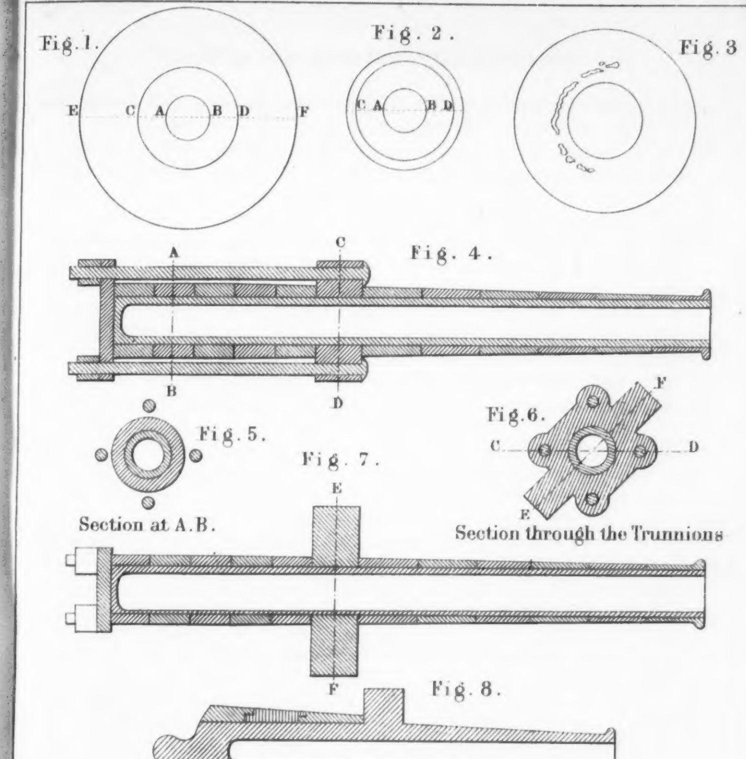
Fig. 1.
E
C
A
B
D
F
Fig. 2.
C A
B D
Fig. 3
Fig. 4.
A
B
C
D
Fig. 5.
Section at A.B.
Fig. 6.
C
D
E
F
Section through the Trunnions
Fig. 7.
E
F
Fig. 8.
Fig. 9.
Fig. 10.
Fig. 11.

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beyond 1·8127; but, having been originally only 1·8074, this will suffice to strain it as much as the inside—53 in 18,074, or 1 in 337.

By this simple contrivance the outside could be made to perform in this case eight times as much work as if it were cast in one piece with the rest, or merely accurately fitted on.

When the outer diameter of the inner tube is stretched to 1·8127 inches the inner diameter of the outer tube must also become 1·8127 inches. If it is originally 1·8120 inches, it is then extended 1 in 2,588; but, if only the $\frac{1}{200}$ of an inch less, or 1·8074 inches originally, then it is stretched 1 in 337.

We could, of course, regulate the extension of the two cylinders so as to be equal with any other amount of pressure; or we could make a greater number of cylinders, thin or thick, all expand equally with a certain amount of strain, by making the inside of each less than the outside of the one under it by a certain very small quantity.

Nothing is easier than to put one tube over another, though the outside of the lesser one be slightly larger than the inside of the other. The application of heat will expand the latter; and, when in position, the withdrawal of the heat will permit it to shrink and grasp the inner tube so tightly as to compress it. This operation is, however, uncertain in its effect; in practice, therefore, I would make the outer surface of one tube, and the inner surface of the other, slightly conical or tapering, and force one over the other with a hydrostatic press. The amount of strain and stretching can thus be accurately adjusted.

The method of constructing cannon which I to-day submit to your judgment is, then, simply to form such parts of them as require great strength of concentric tubes, each slightly too small to go over the one below it without force; *the amount of this difference in size being so regulated that with a certain amount of pressure each tube shall be equally strained*, or that the outside (which can be replaced if broken) shall be most strained. One of these tubes should extend the entire length of the gun, the others may be formed of more convenient sizes. I will presently show various ways in which I arranged them for experiment.

I am told that the introduction of steel for the manufacture of cannon renders my invention unnecessary. I am, however, inclined to believe that, the more valuable is the metal employed, the less John Bull will like to pay for its being so used that it cannot do an eighth of its work; particularly as it requires more skill and more expensive machinery to make guns in one huge mass, of which much is useless, than it does to make them in several pieces so constructed that each shall perform nearly all the work of which it is capable.

I must here state that since I last had the honour of addressing this Institution, I have discovered from the book I have already referred to, "Reports of Experiments on Metals for Canon," published in America in 1857, that I am not the first person who proposed a remedy for the unequal straining of the parts of a gun. In 1851 Lieutenant Rodman of the United States Ordnance proposed, *for that purpose*, to cast guns hollow and cool them from within. On the 30th July of that year, at his suggestion, an eight-inch gun was cast hollow by means of a core formed on a tube of cast iron. Through this a stream of water was kept circulating

until the gun was cool. By this means Mr. Rodman made the inside solidify first. The next layer solidified, of course, at a greater temperature than that of the extreme inside at that moment, as this had already had a short time to cool and contract.

Had the outside of the gun been kept liquid until all the rest had gradually become solid, giving out all heat through the core only, doubtless the gun would have been in a condition very nearly approaching that required by theory, so far as the initial tension on the external portions is concerned. As it was, the gun was much stronger than another cast solid at the same time, of the same size, and of the same metal. The latter burst after 73 rounds with 10 pounds of powder and one 64-pound shot; that cast hollow was fired 1,500 times with the same charge, and is, I believe, still sound.

Not only then did Mr. Rodman forestall me in the idea of remedying the evil of unequal strain in cannon, but he proposed a really efficient remedy. I believe that my remedy is better, cheaper, and adapted to guns very much larger than the other; but I must still be content to occupy the second place in the discovery and application of this principle of construction. It is lucky for my *amour propre* that Mr. Rodman's scientific attainments are of that order that to follow him at any distance is an honour.

On the 21st August, 1851, two ten-inch guns were cast at New York from the same metal, one solid and one hollow. The latter was cooled from within like the eight-inch gun, but the outside was also allowed to cool, though more slowly. These guns were proved by repeated firing with 18 lbs. of gunpowder and one 124 lb. shot.

The gun cast solid burst at the twentieth round, the other stood 249 rounds. When examined afterwards, the gun cast hollow was found to be, in one part, fissured, as shown in section in fig. 3, the outside and inside having solidified before the middle. It is probable that even where no absolute fissure was found, the portion of metal intermediate between the two cooling surfaces was less dense than it should have been.

One advantage my plan certainly has: I can use, to obtain the greater part of the resistance required, a metal much stronger than cast iron, while retaining that metal for the interior of the tube, for which part it is so suited; thus securing the hardness and inflexibility of cast iron, and the tensile force of the toughest steel. Wire even, the strongest form of iron or steel, can be used with great advantage in some cases.

The saving in size of guns, therefore, in expense of transport would be enormous. This is, however, a very small matter, in my opinion, compared to the advantage of, by this means, being enabled to make cannon of a size and strength hitherto impossible, and still impossible by any means which do not ensure that each part shall do its work.

Nothing would be so conducive to peace as arming the vulnerable parts of every coast with guns so powerful that one or two shells from them could destroy a ship. Few have any idea how inadequate to the end desired are the means often employed.

The conflict which took place between the "Guillaume Tell" (afterwards the "Malta") and the "Foudroyant" 74, the "Lion" 64, and the "Penelope" frigate, during the last war with France, supplies an example:

The "Foudroyant" ranged up alongside about 6 A.M., approaching the French ship so closely that her spare anchor just escaped catching in the mizen rigging of the "Guillaume Tell."

The action was continued closely till 8·20 A.M., when the "Guillaume Tell" struck. On this occasion the "Foudroyant" expended—

1,200	32-pound shot
1,240	24-pound do.
118	18-pound do.
200	12-pound do.

Being a total of 2,758 shot, weighing 72,584 lbs., fired at short distances, besides those fired from the batteries of the "Lion" and the "Penelope;" yet the "Guillaume Tell" was not sunk, nor so much injured as to be incapable of service soon afterwards in the British navy.*

Wishing to-day to abstain entirely from theory, I will not speculate on what would have been the fate of any ten ships if fired into for two hours and twenty minutes from a few 24-inch shell-guns, but will, as concisely as I can, give an account of some experiments made to prove the practicability of making such.

My first experiment was to shrink a heated wrought-iron ring over one of cast iron. The result was the compression of the latter to an extent I by no means expected, the wrought iron being only slightly expanded. When separated, both tubes regained their original size.

I next made an 18-pounder gun, of which fig. 4 shows the longitudinal section. It was formed of a tube of cast iron, $5\frac{1}{4}$ inches inner diameter, and $1\frac{3}{4}$ inch thick, over which were shrunk, side by side, short cylinders of wrought iron, the thickest of which was 2 inches.

To resist the force of the gunpowder, therefore, this gun had a total thickness, where strongest, of only $3\frac{3}{4}$ inches; that of a service cast-iron 18-pounder being upwards of $5\frac{1}{2}$ inches. Yet the lesser thickness was quite sufficient, even though the initial strain, calculated as necessary on the outer tubes, had been but very roughly approximated.

As a cast-iron tube, $1\frac{3}{4}$ inches thick, was insufficient to resist the longitudinal strain, and as the wrought-iron cylinders were not joined, but merely placed side by side, four rods were used to give additional strength lengthways. These were fastened at one end to a ring carrying the trunnions, and at the other to an iron plate, which they pressed against the breech end of the gun. Two of these rods and the trunnions are not shown in the longitudinal sections, but are seen in the cross-sections. This gun was much stronger than necessary at the front part; indeed everywhere, except just round the seat of the charge. I regret, now, that I only fired it enough to prove that it was an efficient 18-pounder gun; had I continued till it burst, its strength relatively to service-guns would have been more definitely known. Being desirous, however, before injuring it to find out if a still thinner cast-iron core would suffice, I had this 18-pounder bored out to the size of a 24-pounder. Unluckily, in so doing the bore was not made in the centre, only half-an-inch of cast iron being left at one side of it (see fig. 7). Even in this state, however, it bore, without injury, several hours firing with charges varying from one shot and four pounds of powder, to one shot, two wads, and eight pounds of powder. It burst at the third round with the latter charge. This

* Charnock's Life of Nelson.

great strength was unexpected, the thickness of metal round the charge being only 2½ inches; whereas, in a service 24-pounder it is upwards of 6 inches. My gun, too, had much less windage. It weighed 15 cwt., less by 5 cwt. than the reamed-out 24-pounders which are used with a service-charge of 2 lbs. 8 ozs. of powder. The iron service 24-pounder for an eight-pound charge weighs 48 cwt.

The next experiment I made was to get a 9-pounder service-gun turned down cylindrical from the trunnions to the breech, and on this part to place wrought-iron tubes nearly the exact size and weight of the portion of metal removed, but just the necessary fraction of an inch smaller. Fig. 8 shows this gun in section. The wrought-iron tubes had dove-tailed flanges, so that the one clasping the other gave some longitudinal strength; not that I think this was necessary. Indeed, if outer tubes had been placed merely half-way to the trunnions, strength enough would have been attained. This gun was fired as follows:—

2	rounds with	8	lbs of powder	and	2	shot
86	„	3	„	„	1	„
26	„	4	„	„	1	„
5	„	5	„	„	1	„
5	„	5	„	„	2	„
318	„	6	„	„	2	„
1	„	6	„	„	3	„
1	„	6	„	„	4	„
1	„	6	„	„	5	„
1	„	6	„	„	6	„
1	„	6	„	„	7	„
1	„	6	„	„	8	„
1	„	6	„	„	9	„
158	„	6	„	„	10	„

A cast-iron service-gun, of about the same size and weight, was fired, round for round with this gun until the 110th round, with six pounds of powder and two shot, when the cast-iron gun burst. The superiority of mine was so evident, that Her Majesty's Government had a 68-pounder and a 10-inch gun made almost on the model of it. The 68-pounder made in 1857 will, I hope, be tested this year or next.

A comparison of figs. 7 and 8 will justify my own astonishment at the strength of the 15 cwt. 24-pounder.

My fourth gun was an 18-pounder, of which fig. 9 shows a section of the breech end. The inner cast-iron tube was only 1 inch thick, and open at both ends, the breech being closed by a plug. This was decidedly a mistake, throwing too great a strain on the four longitudinal bolts with which this gun, like my first, was provided, though these are not shown in the figure. Over the cast-iron tube I put two layers of wrought-iron tubes; the first, broad, thin tubes (five-eighths of an inch thick), the outer ones, thicker and shorter. By making the two layers break joint, additional stiffness was obtained. This gun was fired—

1	round with	6 lbs.	of powder	1 wad	and 1	shot
1	„	9	„	„		„
1	„	10½	„	„		„
1	„	12	„	„		„

At this round the four bolts gave way, although each was $2\frac{5}{8}$ inches thick—the four united being equal to a solid bar the size of the bore of the gun. The rest of the gun was uninjured, so that this trial was a great success so far as the method of obtaining lateral strength was concerned, the sides being at the thickest part only $3\frac{5}{8}$ inches thick. The charge which broke this gun was twelve pounds of powder—double the service-charge for guns more than double the weight, and four times the service-charge of the 21-cwt. service-gun. I had this gun remade with four bolts of the best charcoal iron; but they, too, broke without injury to the tubular part. Though so far most satisfactory, this result made me decide not again to leave the entire longitudinal strain to be borne by outer bars.

My fifth gun, which I made in 1856—those I have mentioned having been made in 1855—was a 12-pounder. The longitudinal strain I divided between four bars, attached as in former guns, and the cast-iron central tube which took half this strain, its breech-end, to insure this, having an aperture only half the size of the bore (see fig. 10). This gun had two layers of wrought-iron cylinders.

The manufacture of this gun showed me the great uncertainty of the result of shrinking heated iron tubes. Those for this gun had been made of the same iron, carefully bored to the same diameter, and heated equally; yet about two feet in front of the breech they had compressed the cast-iron core so much more than in other parts, that the bore was there $\frac{1}{10}$ of an inch less. This determined me in future always to force the outer tubes on cold, making the outside of the inner tube a little conical, tapering towards the breech-end. Great accuracy can thus be obtained. Indeed, the method of heating and shrinking on the tubes I had only adopted as a cheaper makeshift for the first few experimental guns. Knowing from former experiments that it would be useless to attempt to burst this gun with ordinary charges, it being much stronger than any former ones, I had long iron cylinders cast and turned accurately to fit the bore. Unfortunately, I had too great confidence in it; and, instead of waiting a day or two and having the compressed part again bored out cylindrical, I fired these closely-fitting cylinders from it. Having put in the powder for the fourth or fifth round, the cylinder was introduced, but stuck in the narrow part, and we could not get it out again. Thinking that the gun was too strong to be burst by gunpowder in any way, I fired it. It burst.

Nothing could have been more injudicious than firing the gun so loaded. Not having any means of calculating the strain on it, nothing would have been proved had it remained sound. I should have been particularly careful, too, of this fifth gun, because I could not afford to make a sixth. This fifth gun proved nothing; but in all the others the increase of lateral, or rather circumferencial, strength by my method of manufacture was great—indeed greater than I had expected.

These guns had been made to test a principle, not as models. They would all have been too light for service, except the 9-pounder. In No. VII. (Vol. II.) of the Journal of the Proceedings of this Institution, page 323, I have given drawings representing the proportions and the method of manufacture I would recommend for large guns—to throw a ton of iron, for instance.

I will here (see fig. 11), therefore, give a drawing of an 18-pounder field and siege gun I should like to see supersede the 38-cwt. gun now used. This gun would have double the strength, would cost less originally, and, weighing only 22 cwt., the transport would require fewer horses. Only the breach-end would require the strength of the double tube; but for some purposes it would be well to have a few guns made as light as possible. In these the principle should be applied the whole length of the gun. By using wire the weight of an 18-pounder gun could with safety be reduced from 38 cwt. to 8 cwt.

Shortly after I had taken my patent for cannon (February 1855), Mr. James Longridge took one for making hydraulic presses on the same principle. To test it he had some small brass cylinders cast (some are on this table), one inch in diameter and one-tenth of an inch thick. Round these he coiled steel wire with a tension calculated to make each coil share in the work. When filled, the cylinders could each contain 300 grains of the strongest sporting gunpowder. He put a certain portion of gunpowder into these, then at each end placed a copper globe, ground to fill up the aperture accurately, with the exception of a small touch-hole. The whole was then bound together by a strong wrought-iron strap, the section of which was about $2\frac{1}{2} \times 1\frac{1}{2}$ inches, and the balls keyed tight up to their seats by a jib and cottar. The powder was then exploded with the following results:—

EXPERIMENTS WITH BRASS CYLINDERS AND STEEL WIRE.

No. of Experiments.	No. of Cylinders.	No. of Coils of Wire, &c.	Charge of Powder.	Results.
			Grains.	
1	1	Without wire . . .	50	Slightly bulged.
2	„	ditto . . .	60	ditto
3	„	ditto . . .	70	Ditto to $1\frac{5}{16}$ outer diameter.
4	„	ditto . . .	80	Ditto to $1\frac{7}{16}$ ditto
5	„	ditto . . .	90	Burst.
6	2	2 coils $\frac{1}{64}$in. wire . .	90	No effect.
7	„	Ditto, one end of wire loose	100	Bulged at loose end and wire uncoiled.
8	3	Without wire . . .	70	Bulged to $\frac{11}{32}$.
9	4	6 coils of $\frac{1}{64}$in. wire .	100	No effect.
10	„	ditto . . .	110	ditto
11	„	ditto . . .	120	Ditto, end of wire came loose.
12	5	Same cylinder as No. 4 but only 1 coil of wire.	100	Burst, end of wire was badly fastened and wire uncoiled.
13	6	2 coils of $\frac{1}{32}$in. wire .	100	No effect.
14	„	ditto . . .	120	ditto
15	„	ditto . . .	130	ditto
16	7	4 coils of $\frac{1}{32}$in. wire .	120	ditto
17	„	ditto . . .	130	ditto
18	„	ditto . . .	140	ditto
19	„	ditto . . .	150	ditto
20	„	ditto . . .	160	ditto
21	„	ditto . . .	180	ditto
22	„	ditto . . .	200	ditto

From this we see that the same cylinder which, unsupported, was

bulged by 50 grains of powder, and burst by 90 grains, could bear the explosion of 200 grains when reinforced by four coils of wire, each only one thirty-third of an inch thick. The initial strain on each coil being so adjusted that each was equally strained with the greater charge. For this purpose the first coil was put on with a slight strain, the next with a greater, the third with a greater still, and so on.

Mr. Longridge next experimented with cast-iron cylinders, one inch in diameter and one-tenth inch thick, but close at one end. The other he secured much in the same way as in the brass cylinders. When filled these cylinders could hold 305 grains of powder. They were strengthened with iron wire coiled on with the requisite increasing tension. The following were the results of the experiments.

EXPERIMENTS WITH CAST IRON CYLINDERS AND IRON WIRE.

No. of Coils of Wire.	Charge of Powder.	Results.
	Grains.	
8 Coils, No. 21 wire gauge . .	200	No effect.
ditto	220	ditto
ditto	240	ditto
ditto	250	ditto
ditto	260	ditto
ditto	270	ditto
ditto	280	ditto
ditto	290	ditto, hoop on flange shifted.
4 Coils, No. 21 wire gauge . .	200	No effect.
ditto	210	ditto, cracked in flange.
Without wire	40	No effect.
ditto	50	ditto
ditto	60	ditto
ditto	70	ditto
ditto	80	Burst.

With eight coils of No. 21 iron wire, then, it appears that these cylinders could bear the explosion of 95 per cent. of as much gunpowder as could be put into them.

To find if it was the material which gave this strength, and not the method of making each part do its work, Mr. Longridge obtained a piece of the best wrought-iron, and made a cylinder similar to the others in size of bore, but with sides *twenty times as thick*. This burst with a charge of 100 grains of powder.

Mr. Longridge next made a three-pounder gun of a copper tube, with iron wire coiled on it. It was meant to be fired with its breech abutting against some resisting substance; but at Woolwich they fixed it with the front flange resting against a piece of timber, and, of course, blew the breech off. To test the strength of this cylinder Mr. Longridge afterwards loaded it, buried it in the earth between two strong pickets firmly driven in, and fired the charge. It showed enormous strength.

Mr. Longridge next made a gun of a thin cast-iron tube, with wire coiled round it. It weighed only 3 cwt., yet threw a 9-pound shot 1,500 yards.

Last year, with his permission, I exhibited here a 6-inch hydraulic press, which he had made of cast-iron three-quarters of an inch thick, with wire coiled round it with a carefully-calculated increasing strain to a thickness of half an inch. This press was sent to a gentleman at Glasgow to be tested; he reports that it has borne a pressure of upwards of seventeen tons per inch! One-fourth of this would have destroyed most cast-iron cylinders of treble the thickness.

Time, I regret, will not permit me to describe any other of Mr. Longridge's valuable experiments. I will only mention one more experiment to-day, but that a most important one, because made by Colonel Treuille de Beaulieu, a distinguished French artillery officer, and one of the *Comité d'Artillerie* of France. He had a 32-pounder (French 30-pounder) turned down cylindrical from the breech to near the trunnions. Over this he shrunk steel tubes, accurately bored.

At first sight this looks very like my plan (see fig. 9); but I regret to say that I cannot quite agree with Colonel Treuille in his method of construction.

The steel he uses is very tough, and similar to that wonderful metal now made so inexpensively by the Mersey Steel Company. Like it, it can be stretched one-fifteenth of its length without breaking, and one one-hundred-and-fiftieth without losing its elasticity. Colonel Treuille made his outer tubes only one three-hundredth of their diameter less than the outside of the cast-iron cylinder. This was about 16½ English inches in diameter; the bore of the gun being about 6½ inches. Now, this cast-iron cylinder is thicker in proportion to its bore than any of those Major Wade tried. The outsides of his were stretched but one-eighth as much as the inside, *when free to expand.* I do not think that in Colonel Treuille's 32-pounder, therefore, the outside of the cast-iron cylinder, encompassed by a strong steel envelope, can expand more than one-tenth as much as the inside of the gun. Granting, even, that his cast iron can be stretched 1 in 300 without danger (which I doubt), still the outside would only be increased, even then, 1 in 3,000. One three-hundredth added to one three-thousandth would then be the greatest elongation of the steel possible, without fracturing the inside of the cast iron. Nearly one-half of the strength of the steel is thus made no use of.

As it is, the gun is strong enough to resist any strain by gunpowder in a lateral direction. When Colonel Treuille first showed and explained it to me, I ventured to express an opinion that the breech would eventually be blown back, owing to the great squareness of the end of the bore in French guns. I had the honour of seeing that gentleman, however, a fortnight ago, and was rejoiced to find, as I am sure you will all be glad to hear, that hitherto neither this nor any other catastrophe has occurred. On the contrary, the gun has borne 1,000 proof-charges without the slightest injury except to the vent, which, of course, has been more than once renewed.

Although I think that Colonel Treuille could have obtained equal strength by the use of one-half the quantity of steel, had he made the steel cylinders one four-hundredth part less in diameter, still, as he actually does make them do ten times as much work as if they were not in a constant state of tension, I hope I may fairly consider him as an authority,

and a most weighty one, in favour of the principle of construction I am advocating.

His method of manufacture must not be confounded with that proposed, years ago, by General Thierry, who thought to obtain the rigidity of cast iron and the strength of wrought iron by simply placing tubes of the latter metal over one of the former metal. Guns were so made, which looked exactly like Colonel Treuille's, or mine; yet they were perfect failures. The reason is obvious: the strain was not communicated to the wrought iron, as it had no initial tension, or, at most, only enough to give it a firm hold on the interior.

The difference of opinion between Colonel Treuille and myself is only as to the degree of disproportion between the useful effect of the inside and the outside of cylinders. He thinks that, in the 32-pounder he made, the outside of the cast iron part, which was about 50 inches in circumference, could exert two-fifths as much strength as the inside, which was about 20 inches in circumference; the diminution being in the direct proportion of the diameter. Now, I believe that the diminution is in a greater ratio than even the squares of the diameters; in the above case more than 25 to 4, instead of 5 to 2.

This question is of such importance in deciding the *necessity* of abandoning the present method of making guns by casting, that I trust you will permit me to discuss it a little fully.

Those who, like Colonel Treuille, argue that the strain is in the inverse ratio of the diameter, must believe that the thickness of metal remains constant whatever the pressure; for under no other conditions would one part be exactly as much elongated as another. Even on this view of the case, the outside of a service-gun, which is fully three times greater in circumference than the inside, could only do one-third as much work, because an elongation which would strain a fibre of one length to a certain amount, could only strain a fibre three times as long, one-third as much.

I have already given reasons why the metal must decrease in thickness when strained; I will now, therefore, only refer to Major Wade's experiments (see page 3), which show that in every instance he tried such was the case.

Those who argue that the strain is in the inverse ratio of the squares of the diameters, believe that the thickness of the metal diminishes as the circumference is increased by pressure from within, but that the total bulk of the metal remains constant; and that, therefore, the area of the surface of metal, which would be exposed by making a cross-section through the cylinder, perpendicular to its axis, must be also constant whatever the pressure. Now, on this hypothesis even, the outside of a cast gun could not do more than one-ninth of its work, *yet in all Major Wade's experiments the cross-section was decreased by strain* up to a certain point, which proves that the *useful effect of the metal must have decreased in a greater proportion than even the squares of the distance from the centre.*

Had I not found an account of these experiments, I should have despaired of ever convincing any but persons possessing a knowledge of science that guns are at the present time being cast by thousands in such a manner that fully two-thirds of the metal in them is not only utterly

useless but most mischievous, because rendering their transport more difficult and expensive; *and that the extreme outsides of the present guns cannot exert one-twelfth of the power they could be made to exert.*

These experiments are valuable to me also as establishing the truth of another argument I used here on a former occasion. It is constantly asserted that the pressure of the gas of gunpowder amounts to ten or twelve tons per square inch of surface, and that its action being sudden is more mischievous than an equal pressure applied more slowly. As guns do bear the repeated application of this pressure, I was told that I must exaggerate their weakness. My reply was, that the shot, by moving directly the first particles of powder burn, leaves room for the rest to expand gradually, and that the pressure can never be so great as is said, because such pressure acting through a certain space must necessarily produce a greater velocity than we know is produced. The belief in the great pressure of the products of powder, which has been handed down to us from former generations, must now at last yield to demonstration. Major Wade burst a serviceable 18-pounder gun behind the trunnions with a pressure of $4\frac{1}{2}$ tons per inch. The pressure of the gunpowder must therefore have been less than $4\frac{1}{2}$ tons per inch, or at all events less destructive than that pressure longer applied. This is very important, upsetting all preconceived ideas of the violence of the explosion of gunpowder in the cannon now used. In larger guns the pressure of course would be greater, because the shot would acquire motion more slowly, therefore would leave less room for the igniting powder. Hence the larger the gun the greater the difficulty of getting it to resist the explosion; hence the utter impossibility of making guns beyond a certain size to fire full charges of powder without making more than one layer of metal take its fair share of work.

In rifled cannon this limit is reached in a smaller calibre than in smooth bores, because the resistance of the twist and of the friction prevents the shot moving from its place rapidly enough to leave room for the gas of the powder, which being thus confined exerts more power. This additional power has been turned to advantage by Mr. Armstrong, but has hitherto baffled Mr. Whitworth, in his endeavours to obtain good results from rifled cannon. The 32-pounder and the 68-pounder made by the latter were burst by the pressure in the gun, though the shot was of iron only and not tightly fitting. Mr. Armstrong's guns, on the other hand, bear without injury the much greater pressure resulting from the use of a bullet covered with lead and fitting extremely tight. His bullets, indeed, are made larger than the general bore of the gun, are inserted at the breech end, where the barrel is slightly wider, and are forced by the gas of the powder through the narrower part. The pressure of this gas must be enormous, because the powder must have time to be entirely burnt before the shot moves many inches, resisted as it is.

How then does Mr. Armstrong obtain power, accuracy, great velocity, and extreme range from a pressure much greater than that which destroys Mr. Whitworth's guns? How can he use a pressure capable of giving such velocity to his bullets, that a twist not half so rapid as Mr. Whitworth uses is yet sufficient to ensure accuracy which must be seen to be credited?

I will answer these questions by quoting the words in which Captain

Younghusband, R.A., described the manufacture of Mr. Armstrong's guns to the Royal Artillery Institution in April, 1856:—

"A core, or internal lining for the gun, was formed of cast steel, to which the requisite strength was given by encircling it with twisted cylinders of wrought iron, made in a similar manner to gun barrels, and tightly contracted upon the steel core by the usual process of cooling after previous expansion by heat; *the parts are then in that state of initial tension which is necessary to bring their entire strength into operation.*"

This "initial tension" of the outside of the guns is then the difference between Mr. Whitworth's and Mr. Armstrong's, between failure and unexampled success; and it is this "initial tension" of the outer parts which I have been advocating for upwards of four years, which I have endeavoured to advocate to-day, as not only beneficial but absolutely necessary when great strength is required.

It is but fair to Mr. Armstrong to state, that, judging from dates, his first gun must have been commenced long before I published my views, although after I had taken a patent and made one or two guns. We, therefore, arrived independently at the same conclusion.

Though I claim to share with him the honour of the invention of the means of obtaining *strength* in cannon, yet the marvellous accuracy he attains, the ingenuity and simplicity of his plan for loading by the breech, the perfection of his fuze, the skilful shaping of his shell and of the inside of his barrel, the scientific way in which he secures the great pressure, guarding against any waste of it; these and many other advantages are due to him and to him only (so far as I know), and I am confident you will all join me in hoping he may receive the hearty gratitude of his country for his patient, laborious, most scientific, and most successful researches.

I will conclude by taking the liberty of intreating any of you whom I have been able to convince of the truth of my views to promulgate them. I venture to make this request now, because every cannon foundry in the kingdom is busy making guns which in a year or two must be obsolete; and because, what is far more dangerous, we are planning expensive means of defending our seaports against guns now in use, against guns which we will heed no more than bows and arrows by the time our defences against them are completed. Those defences I need hardly say will be useless against cannon which can be made and which in a year or two will be made.

Friday, January 28th, 1859.

Lt.-Col. T. St. Leger Alcock, Vice-President, in the Chair.

ON THE ORGANISATION OF THE ARMY OF INDIA, WITH ESPECIAL REFERENCE TO THE HILL REGIONS.

By Hyde Clarke, D.C.L.,

Vice-Pres. of the Geologists' Association, Fellow of the Statistical Society, Cor. Mem. of the Institute of Engineers of Vienna, &c., Agent for the English Settlers in the Darjeeling Country.

India for military and topographical purposes must be considered with reference to maritime communication, internal domination, and external aggression.

As the basis of our military power in India is the supply of soldiers of our own race, a free communication with the sea must be kept up, and the command of the seaports be held by us. The command of the seaports and of the broad river channels and deltas, is not however mainly dependent on a military force, as it can be kept up by the naval department.

Except in the Dekkan, the main military stations are far remote from the seaports, and in the north, the rivers Burhampooter, Ganges, and Indus form at present the channels of communication.

Within the territory of India, military stations and arsenals must be formed for holding the population in check.

On the sea-frontier, there is at the present moment little danger from external aggression, even in case of a war with France; but on the circle of the northern frontier, are the hostile or threatening populations of the wild tribes and of the Chinese; but, what is of far greater importance, we have to provide against the advances of the Russians, as ambitious as ourselves, and whose ambition is not sated with the acquisition of the intervening countries, but has for its special object the domination of India, by the introduction of an invading military force and by raising the local populations.

Thus any plan for the military organization of India must provide for all the objects here defined; but there is no such organization for India, as its military administration has grown up piecemeal, as our empire has extended, accommodating itself to circumstances, and mainly dependent on the incorporation of a large body of native soldiery. So long as this state of affairs remained, the organization of the administration was impeded by many obstacles, and, it is almost needless to say, was attended with imminent danger, as great under any change as under the existence of the then system.

We may be disposed to think, that, as a revolt of the native army was inevitable, it was fortunate it happened when it did. It settled conclusively the policy of dependence on a native force, and it happened just at

the period when our acquisitions of territory placed us in a situation to form our establishments in positions suited to our own wants, instead of being obliged, as before, to conform to the requirements of a native army. Thus heretofore the stations were selected to suit the tropical constitutions of the native army, and not the constitutions of our own men. The arsenals were consequently placed, as at Delhi for example, within the command of an unreliable force.

If the governors of India choose, the re-organization of the Indian armies can proceed unshackled by the former system, and on such bases as, in a political and military point of view, are most consistent for our own objects.

Considered politically, our purpose must evidently be, so far as practicable, to dispense with the native element; and to rely upon the European element, as the constituent of the military force. To effect this we must place the Europeans where they can be healthy and efficient; and in doing so we have this advantage, that such stations are unfavourable generally to the native troops. So far as the main purposes of the army of India are concerned, this can be done, with the additional advantage, of securing the country from external aggression and internal insurrection.*

India as a military province consists of the two divisions of the lowlands or tropics, and uplands or temperate regions. Hitherto the tropical regions have been occupied by our garrisons, and the graves of our men; the uplands, recently acquired, and little occupied by the people of the plains, have received small attention, and have not, therefore, been fully considered in reference to their military relations. They have been in some places selected for invalid depots, but, strangely enough, the very experience which proves their fitness for garrisons has been little regarded, except by the medical authorities; and to men eminent for their scientific endowments and their zealous and disinterested exertions for the benefit of their fellow-countrymen—to such distinguished men as Julius Jeffreys and Ronald Martin, we owe the formation of establishments, and the progress of public opinion, which now enables us seriously to contemplate the introduction of a European force into India, as a necessary and practicable measure.

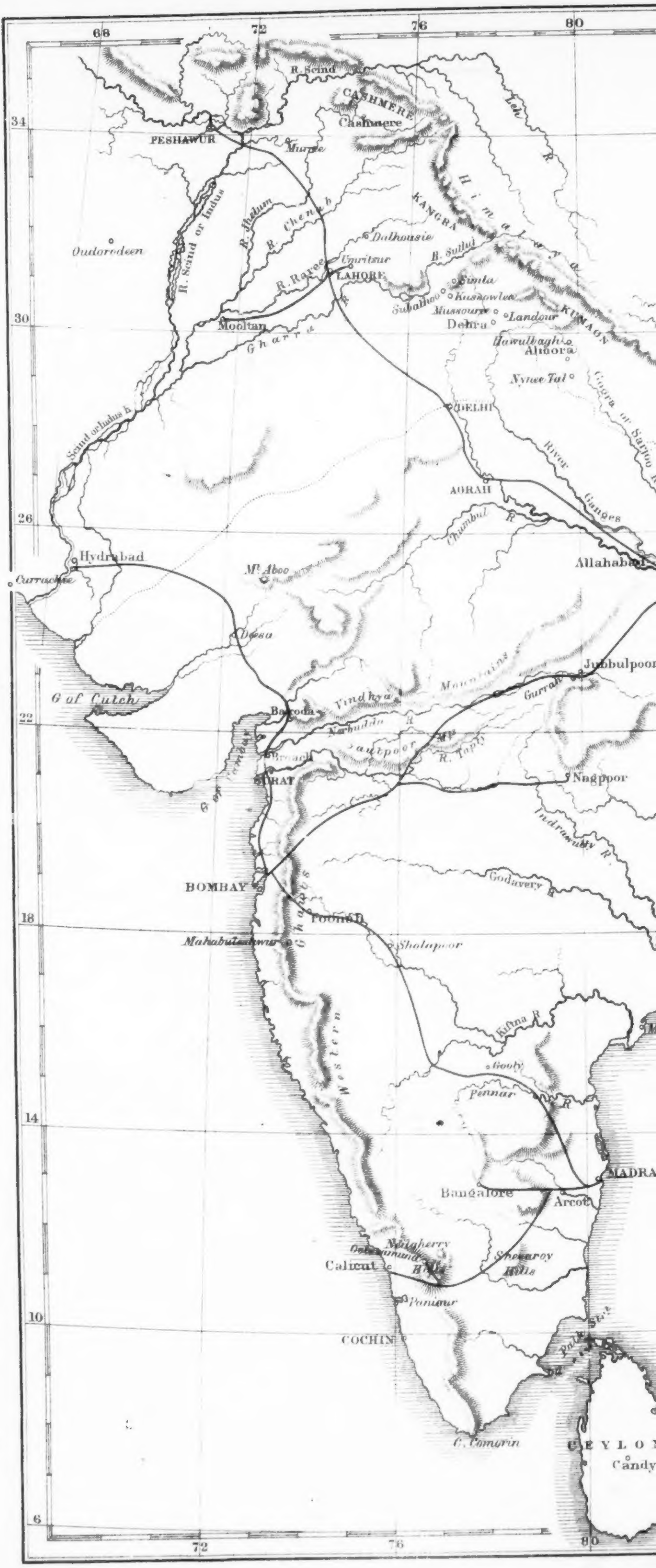
Again, the individual researches of the officers of our army, and even their sports and love of adventure, have contributed to make known to us these hill countries, and to prove their adaptation for English occupation. There are, however, few of us who have contemplated the extent of the hill regions as a whole, their resources, and their importance for military purposes. We rather regard the difficulties, the temporary obstacles, want of communication, the barrenness of some districts, the scanty population of others, the remoteness which seems to shut them off from English settlement. We have so long looked at India through false media, that we cannot contemplate the government of India in its right aspect. We are willing enough to accept the occupation of Fraser River, to believe in the advancement of Australia, to speculate on the spread of the English race through the south of Africa; but India has been too long believed to be the tomb of the Englishman, for us to be ready to regard any portion of it as his home.

* Indian Railways, Colonization, and Defence. By Hyde Clarke, 1856.

Let us take Bengal,—our military view of it is as a chain of garrisons and arsenals on the Ganges, supplied from Calcutta and communicating by the river, and this we take as an accepted fact; yet, it is not one which we should be readily disposed to allow, if we took a broader view of the resources of the country. Let us next pass from the north to the Dekkan. There we have the long line of the Western Ghauts close to the coast, accessible from numerous ports, and having a naval station at Bombay. On these Ghauts, and on the table-land attached, are places of moderate temperature, suitable for English occupation, and there is no military reason why the stations should not be there placed, instead of in the lowlands of Madras. Stations on these Ghauts, as those in the neighbourhood of Poonah for example, are accessible from the sea, and command the Malabar coast, and are convenient depots for commanding the country to the east, the rivers of which, rising in the Western Ghauts, flow from west to east, and are therefore more easily to be penetrated from the upper ranges than by moving upwards from the Coromandel coast. The stations on the Coromandel coast, first occupied by Europeans, as Madras and Pondicherry, command, it is true, the commercial outlets for produce, but as garrisons they lie at the foot of the hill country, which embarrasses the movements upwards, and any lateral movement along the coast must be made across river deltas, or across successive river channels. Thus for all districts south of the Kistnah, the military force should be stationed in the western high districts, where the troops can be kept healthy and efficient. Already troops landed at Bombay can be at once carried up to Poonah by railway, and down for embarkation for Kurrachee, for stations on the coast, and for return to England.

What has been provided for Bombay can be provided for other parts of the Malabar coast; and railways running up from the shore, would at once place the Europeans in a European climate, ready to descend on the districts of the interior. This plan is already laid down for the southern part of the peninsula, where a branch of the Madras Railway will connect the Neilgherries and Shevaroys with the ports on the Malabar shore, which are now accessible to coasting steamers. Thus it will be seen, that a base of operations has been already constituted, which will change the whole military administration of the south of India. If indeed commanders-in-chief are appointed for the two southern presidences, the one will be stationed with his staff, not at Bombay, but at Poonah, and the other, not at Madras, but on the Neilgherries or the Shevaroys.

By placing other stations on the Ghauts, and having communications with them, the whole of southern India will be held by an English force co-operating with the Indian navy, in ordinary times, traversing the presidencies by railway, in times of difficulty, holding the natural strong places of the country, and sweeping the river valleys. In the hills will be the invalid establishments, the military schools, and the residences of the officials, and the expenditure on this account will afford resources for maintaining a large civil population. The hill tribes are few and weak, and the country is left open for English occupation. Attached to these hill fastnesses are the table-lands of Mysore and other districts, in which coffee and tea cultivation is extending, and in which English capital and enter-



68
72
76
80
34
30
26
22
18
14
10
6
R. Scind
CASHMERE
Cashmere
Leh
PESHAWUR
Murree
KANGRA
Himalaya
R. Scind or Indus
R. Jhelum
R. Chenab
Dalhousie
Oudoreeleen
Umritsur
LAHORE
R. Sutlej
R. Ravee
Simla
Kussowlee
Subathoo
Mussourie
Landour
Dehra
KUMAON
Mooltan
Gharra
Hawulbagh
Almora
Nynee Tal
DELHI
Scind or Indus R.
River
Ganges
AGRAH
Chumbul R.
Allahabad
Hydrabad
Currachee
Mt Aboo
Deesa
Jubbulpoor
G. of Cutch
Baroda
Vindhya
Mountains
Gurrah
Nerbudda R.
Broach
Saatpoor
R. Tapty
SURAT
Nagpoor
G. of Cambay
Indrawutty R.
Godavery R.
BOMBAY
Poonah
Mahabuleshwur
Sholapoor
Kistna R.
Western
Ghauts
Gooty
Pennar R.
MADRAS
Bangalore
Arcot
Neilgherry Hills
Calicut
Shevaroy Hills
Paniaur
COCHIN
Palk Str.
C. Comorin
CEYLON
Candy


MAP OF THE
HILL GROUPS OF INDIA.
with the
INTENDED RAILWAY ROUTES.
British Miles.
0 50 100 200 300
Long. E. from Greenwich
80
84
88
92
34
30
26
22
18
14
10
6
Sanpoo R
KUMAON
Mountains
Gogra or Sanpoo R
Gunduck R
River Ganges
SIKKIM
Darjeeling
Brahmaputra R
ASSAM
SYLHET
Sylhet
Allahabad
Benares
Patna
Jubbulpoor
Raneegunge
CALCUTTA
Dacca
Mouths of the Ganges
Nagpoor
Mahanuddy R
Masulipatam
MADRAS
Arcot
CEYLON
Candy
J.R.Jobbins

Friday, January 28th, 1859.

Lt.-Col. T. ST. LEGER ALCOCK, Vice-President, in the Chair.

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Vice-Pres. of the Geologists' Association, Fellow of the Statistical Society, Cor. Mem. of the Institute of Engineers of Vienna, &c., Agent for the English Settlers in the Darjeeling Country.

India for military and topographical purposes must be considered with reference to maritime communication, internal domination, and external aggression.

As the basis of our military power in India is the supply of soldiers of our own race, a free communication with the sea must be kept up, and the command of the seaports be held by us. The command of the seaports and of the broad river channels and deltas, is not however mainly dependent on a military force, as it can be kept up by the naval department.

Except in the Dekkan, the main military stations are far remote from the seaports, and in the north, the rivers Burhampooter, Ganges, and Indus form at present the channels of communication.

Within the territory of India, military stations and arsenals must be formed for holding the population in check.

On the sea-frontier, there is at the present moment little danger from external aggression, even in case of a war with France; but on the circle of the northern frontier, are the hostile or threatening populations of the wild tribes and of the Chinese; but, what is of far greater importance, we have to provide against the advances of the Russians, as ambitious as ourselves, and whose ambition is not sated with the acquisition of the intervening countries, but has for its special object the domination of India, by the introduction of an invading military force and by raising the local populations.

Thus any plan for the military organization of India must provide for all the objects here defined; but there is no such organization for India, as its military administration has grown up piecemeal, as our empire has extended, accommodating itself to circumstances, and mainly dependent on the incorporation of a large body of native soldiery. So long as this state of affairs remained, the organization of the administration was impeded by many obstacles, and, it is almost needless to say, was attended with imminent danger, as great under any change as under the existence of the then system.

We may be disposed to think, that, as a revolt of the native army was inevitable, it was fortunate it happened when it did. It settled conclusively the policy of dependence on a native force, and it happened just at

the period when our acquisitions of territory placed us in a situation to form our establishments in positions suited to our own wants, instead of being obliged, as before, to conform to the requirements of a native army. Thus heretofore the stations were selected to suit the tropical constitutions of the native army, and not the constitutions of our own men. The arsenals were consequently placed, as at Delhi for example, within the command of an unreliable force.

If the governors of India choose, the re-organization of the Indian armies can proceed unshackled by the former system, and on such bases as, in a political and military point of view, are most consistent for our own objects.

Considered politically, our purpose must evidently be, so far as practicable, to dispense with the native element; and to rely upon the European element, as the constituent of the military force. To effect this we must place the Europeans where they can be healthy and efficient; and in doing so we have this advantage, that such stations are unfavourable generally to the native troops. So far as the main purposes of the army of India are concerned, this can be done, with the additional advantage, of securing the country from external aggression and internal insurrection.*

India as a military province consists of the two divisions of the lowlands or tropics, and uplands or temperate regions. Hitherto the tropical regions have been occupied by our garrisons, and the graves of our men; the uplands, recently acquired, and little occupied by the people of the plains, have received small attention, and have not, therefore, been fully considered in reference to their military relations. They have been in some places selected for invalid depots, but, strangely enough, the very experience which proves their fitness for garrisons has been little regarded, except by the medical authorities; and to men eminent for their scientific endowments and their zealous and disinterested exertions for the benefit of their fellow-countrymen—to such distinguished men as Julius Jeffreys and Ronald Martin, we owe the formation of establishments, and the progress of public opinion, which now enables us seriously to contemplate the introduction of a European force into India, as a necessary and practicable measure.

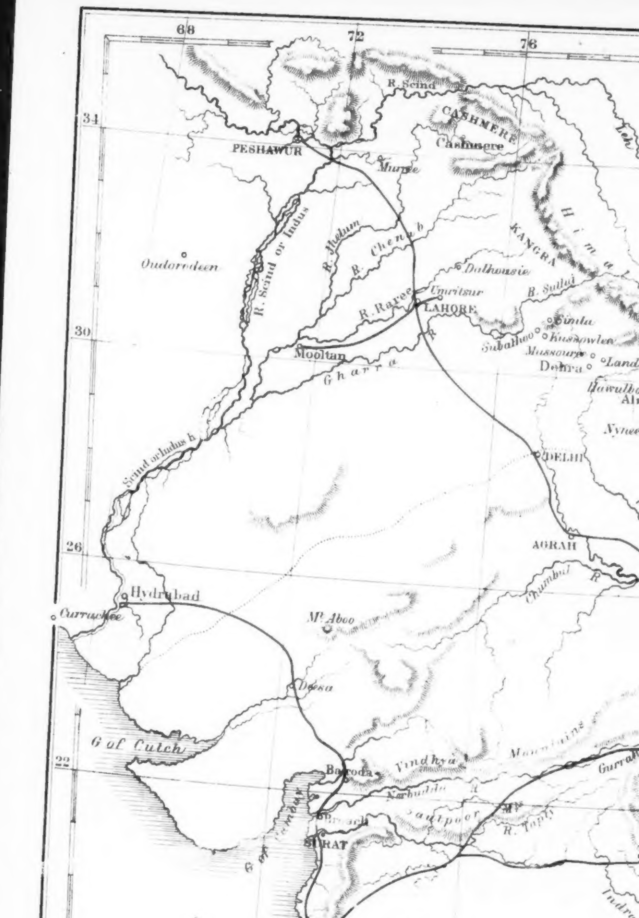
Again, the individual researches of the officers of our army, and even their sports and love of adventure, have contributed to make known to us these hill countries, and to prove their adaptation for English occupation. There are, however, few of us who have contemplated the extent of the hill regions as a whole, their resources, and their importance for military purposes. We rather regard the difficulties, the temporary obstacles, want of communication, the barrenness of some districts, the scanty population of others, the remoteness which seems to shut them off from English settlement. We have so long looked at India through false media, that we cannot contemplate the government of India in its right aspect. We are willing enough to accept the occupation of Fraser River, to believe in the advancement of Australia, to speculate on the spread of the English race through the south of Africa; but India has been too long believed to be the tomb of the Englishman, for us to be ready to regard any portion of it as his home.

* Indian Railways, Colonization, and Defence. By Hyde Clarke, 1856.

Let us take Bengal,—our military view of it is as a chain of garrisons and arsenals on the Ganges, supplied from Calcutta and communicating by the river, and this we take as an accepted fact; yet, it is not one which we should be readily disposed to allow, if we took a broader view of the resources of the country. Let us next pass from the north to the Dekkan. There we have the long line of the Western Ghauts close to the coast, accessible from numerous ports, and having a naval station at Bombay. On these Ghauts, and on the table-land attached, are places of moderate temperature, suitable for English occupation, and there is no military reason why the stations should not be there placed, instead of in the lowlands of Madras. Stations on these Ghauts, as those in the neighbourhood of Poonah for example, are accessible from the sea, and command the Malabar coast, and are convenient depots for commanding the country to the east, the rivers of which, rising in the Western Ghauts, flow from west to east, and are therefore more easily to be penetrated from the upper ranges than by moving upwards from the Coromandel coast. The stations on the Coromandel coast, first occupied by Europeans, as Madras and Pondicherry, command, it is true, the commercial outlets for produce, but as garrisons they lie at the foot of the hill country, which embarrasses the movements upwards, and any lateral movement along the coast must be made across river deltas, or across successive river channels. Thus for all districts south of the Kistnah, the military force should be stationed in the western high districts, where the troops can be kept healthy and efficient. Already troops landed at Bombay can be at once carried up to Poonah by railway, and down for embarkation for Kurrachee, for stations on the coast, and for return to England.

What has been provided for Bombay can be provided for other parts of the Malabar coast; and railways running up from the shore, would at once place the Europeans in a European climate, ready to descend on the districts of the interior. This plan is already laid down for the southern part of the peninsula, where a branch of the Madras Railway will connect the Neilgherries and Shevaroys with the ports on the Malabar shore, which are now accessible to coasting steamers. Thus it will be seen, that a base of operations has been already constituted, which will change the whole military administration of the south of India. If indeed commanders-in-chief are appointed for the two southern presidences, the one will be stationed with his staff, not at Bombay, but at Poonah, and the other, not at Madras, but on the Neilgherries or the Shevaroys.

By placing other stations on the Ghauts, and having communications with them, the whole of southern India will be held by an English force co-operating with the Indian navy, in ordinary times, traversing the presidencies by railway, in times of difficulty, holding the natural strong places of the country, and sweeping the river valleys. In the hills will be the invalid establishments, the military schools, and the residences of the officials, and the expenditure on this account will afford resources for maintaining a large civil population. The hill tribes are few and weak, and the country is left open for English occupation. Attached to these hill fastnesses are the table-lands of Mysore and other districts, in which coffee and tea cultivation is extending, and in which English capital and enter-



68
72
76
34
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26
22
18
14
10
6
R. Scind
CASHMERE
Cashmere
PESHAWUR
Murree
R. Scind or Indus
R. Jhelum
R. Chenab
Oudoredeen
KANGRA
Dalhousie
Umritsur
R. Sutlej
R. Raree
LAHORE
Simla
Kussowlee
Mussouree
Dehra
Mooltan
Gharra
DELHI
AGRAH
Chambul
Hydrabad
Currachee
Mt. Aboo
Desa
G. of Cutch
Vindhya
Mountains
Baroda
Broach
SURAT
R. Tapty
BOMBAY
Godavery
Poonah
Mahabuleshwur
Ghauts
Sholapoor
Kistna R.
Gooty
Pennar
Western
Bangalore
Arcot
Neilgherry
Hills
Calicut
Shevaroy
Hills
COCHIN
C. Comorin


MAP OF THE
HILL GROUPS OF INDIA.
with the
INTENDED RAILWAY ROUTES.
British Miles.
0 50 100 200 300
Long. E. from Greenwich
80
84
88
92
34
30
26
22
18
14
10
6
Simla
Kussowlee
Dehra
Landour
KUMAON
Almora
Hawulbagh
Nynee Tal
DELHI
AGRAH
Sanpoo R
Mountains
SIKKIM
Darjeeling
Brahmaputra R
SYLHET
Silhet
Dacca
Allahabad
Benares
Patna
Jubbulpoor
Runeegunge
CALCUTTA
Mouths of the Ganges
Nagpoor
Mahanuddy R
Godavery R
Masulipatam
Kistna R
Pennar
MADRAS
Arcot
Shevaroy Hills
CEYLON
Candy
Comorin
Ganges
Gandak R
Gogra or Sarjoo R
Chumbul R
Tapty
Indrawutty R
Palk Str
Goolly
J R Jobbins

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prize can find scope for exertion. Thus the military force will be backed by a powerful civil reserve, always able to hold the hill stations by militia and volunteers, and to have every man, horse, and gun of the garrisons available for operation in the field as the telegraph summons.* As the English force would be always healthy, its effective strength would be greater, and, as it would require no guards, depots, and detachments for arsenals and reserves, it would be a real field force.

It is very desirable to consider the condition of the southern Presidencies; because, that which elsewhere may be considered novel and experimental, is precisely that which is here being gradually carried out.

In the space here afforded, it is impossible to consider full details; we can only give attention to some of the larger groups; this however is preferable, as it enables us to lay down general principles instead of suggesting details on immature information.

Central India, or the valleys of the Nerbuddah and the Nuddy, has, according to the principles on which we are now arguing, its military stations in the ranges and table-lands on each side of those valleys. At present these ranges are little known and explored, but the progress of the railways uniting Bengal and Madras, will give us better means for becoming acquainted with them. Enough is however known in the certainty, that there are peaks and table-lands of European climate.

One of the first duties of the Government should be the exploration of these ranges, and their occupation by English military establishments and settlements. Recent events will show us the importance of this. We at once interpose a barrier between the native states of the centre and the north-west, commanding the Rajpoots and the Mahrattas, by a double line of posts and settlements strengthened by the Nerbuddah, through which a trunk line of railway would be safely maintained.

From this centre, Nagpore and the northern dominions of the Nizam would be controlled, the Rajpoot states, and the upper country of the Jumna and the Ganges.

In Rajpootana, we have a strong detached position already marked out for occupation, by the station of Mount Aboo. This military region must be extended.

Let us now direct our attention to the groups of hill states and sanataria to the north of Delhi, in which are included Simla, Landour, Mussoorie and Almorah.

By the help of strong garrisons in this district, with the force in the Rajpootana range and the Nerbuddah force, the whole of the upper valleys of the Ganges are effectually commanded. Delhi, Agra, Cawnpore, Allahabad, and the military stations and arsenals attached to them, in this aspect become of minor importance. They command the passes of the rivers, but the hill states command the doabs of the rivers, and the whole of the valleys can be swept. Arsenals in the Vindyha range can be supplied by railway when Delhi is inaccessible, and the communications with Calcutta become less important, when there is the choice of communi-

* Report on Telegraphic Communications in India made to the H. E. I. Co., by Francis Whishew and Hyde Clarke, 1849.

cations from Kurrachee and from Bombay, and even from Surat and minor ports.

In a like way, the hill state nucleus and the Aboo district would co-operate in restraining the valley of the Indus, forming too the second and minor line, on which the outer garrisons in the ranges around the Punjab would repose.

We have now inspected most of India, except the districts of the Lower Ganges and the Burhampooter. There, we have likewise hill stations, already partially occupied, and admitting of extension. Due north of Calcutta, is Darjeeling or English Sikkim, with a healthy climate and productive lands around. This was only a small invalid depot, but is now being converted into an English cantonment. The late Government of India began this policy, but since the accession of Lord Stanley, as Secretary of State for India, the hill cantonments have been considerably extended.

In the middle of the bend of the Burhampooter valley, we have the hill group of Sylhet, which, although of wet climate, admits of being garrisoned and has the advantage of coal mines. In Upper Assam healthy stations are to be found, and there is considerable scope for the formation of English establishments. At the present moment these stations are remote; but all the main military stations of the North-west, of the Punjab, and of Central India, are remote from the coast, and the communication is tedious. The railway line from Calcutta to Darjeeling, called the Northern Bengal, only requires the construction of two hundred miles of railway, and then it gives access, not only to Darjeeling, but to Assam, and the upper valley of the Burhampooter.

Thus the whole of India can be formed into military districts, having strong centres with English troops, and civilians constituting reserves, and affording, for internal or external movements, several armies kept ready for the field, instead of being employed as now in moving idly about India and garrisoning unhealthy fortresses.

The rapid communication and transit of these armies and of their material, must be provided by railways, in substitution for the existing method of long land-marches with countless followers, or of steamboat conveyance on the great rivers. Some have a preference for river steamers, and an objection to railways, because railways can easily be obstructed. It is however forgotten, that in time of war, as has been lately exemplified, the traffic of a river may be stopped, by a local fortress or a battery of field guns. At all periods, however, river transit is inferior for troops, because it wastes time, and is unfavourable to discipline. One day on a railway will do what fourteen days and nights will do on a river, and there is, after all, a better chance of keeping a railway open than a river. Troops can march past the obstructed portion of a railway, and make use of a further portion; but the steamer that is stopped by a fort, though its passengers may make their way round by the rear of the fort, cannot readily find conveyance again. Railways as military instruments are not inferior to rivers, although we are little accustomed to consider their employment.

For the establishment of a permanent force in India, the measures required are, the formation of more hill cantonments, the further encouragement of hill settlers, and the provision of railways and tramways, which,

first begun for military purposes, will speedily bring a revenue from their civil employment.

The Government now has small stations or cantonments at or in Sylhet, Darjeeling, Almorah, Nynee Tal, Mussorie, Simla, Murree, Mount Aboo, Poonah, and the Neilgherries. In the last years these establishments have been increased, and new cantonments formed at Darjeeling and Nynee Tal.

The main trunk railways, fortunately enough, form a base for the required extensions, and in some places they afford the necessary communication. Thus the Poonah command is connected with Bombay—the north-east and the south-east. A provision is made for the Neilgherries and the Shevaroys, by the lines in southern Madras. The main line of the East Indian Railway not only provides half of the route to Darjeeling, but runs near the upper hill stations, admitting of branches being readily formed. Through the Dehrah Dhoon, or the district under Simla, should be carried the proposed Simla Railway, so as to keep under command the connection between the East Indian and the Punjab Railways.

The achievement of what is needful, does not require a large expenditure by Government, but it does require liberal encouragement from Government, and a wise administration. Much has been begun, and we have only to persevere in that course of policy to realise the desired results. The hills and table-lands of India afford resources equal to those of any of our colonies, and the public have but to be made acquainted with the facts, to direct thither a portion of that emigration which has created new states in Australia, South Africa, and Canada. Such an emigration of English, Irish, Welsh, and Highlanders, would be, as elsewhere, recruited by Germans, Jews, and the adventurous spirits, who seek protection and prosperity under the flag of England. In many parts of the hill regions the aborigines are few and weak; but in other places, there are numerous hill tribes like the clans of Scotland, having no sympathy with the population of the plains, and who can be made ready allies.

This is one special advantage of the hill system, that, whereas elsewhere in India we must be isolated, in the hills we can easily in a few years, from our own people and the hill tribes, draw together a warlike population of a million, and from which we can safely draw recruits, because the women and children will be left within our own quarters. Such a population would of itself be a great resource, beyond any we now possess, far better than a Sepoy population, far better than the present precarious assistance of Ghoorkas and other hillmen.

It may now be useful to regard the hill positions in reference to their external relations. Thus, in Upper Assam, and on the Burmese frontier, by the proper constitution of our garrisons, we acquire the means of commanding the upper valleys of the rivers of Burmah and Siam—countries with which our intercourse is yearly becoming closer and of more importance to us. In Assam we are not only at the head of the great rivers falling into the Malay seas, and at the head of the Burhampooter, but we are within a very little distance of south-west China, and the valley of the Yang-tse-Kiang. At present a few wild tribes and the difficulties of the mountain passes impede intercourse; but with the removal of these, India will be opened to the teeming populations of China, and the social,

industrial, and political, results of the immigration will be great. We have been accustomed to regard the Hindoo population of Bengal as presenting a mass of millions of men, to whom the institutions of India must be subservient; but a Chinese immigration will produce far different results. Attracted into the Assam valley, by the demand for labour in the tea and other plantations, the Chinese will spread into the valley of the Ganges; and thus we shall, perhaps in a very few years, find the population of India intermixed, and therefore, more plastic to our institutions, than the unmixed indigenous population.

Darjeeling is another most interesting point placed between Bhotan and Nepaul. It secures the former hill country from the ambition of the latter, we may say, for the exercise of our own ambition; for Bhotan, in its distracted state, requires the exercise of English intervention. To eastern Thibet, and Central Asia, Darjeeling commands one of the routes for trade and communication, and it is our barrier against Nepaul.

Nepaul is politically, and practically, one of our great dangers in India. Constantly excited to ambitious designs on India, Nepaul is for the time restrained by the caution of the despot of the moment, but, by its turbulent tribes,Oude, and all our rich provinces on the northern bank of the Ganges are always threatened. So long as this state of affairs exists, Darjeeling must be strengthened, fortresses must be maintained on the Ganges, and the hill sanataria of the Simla ranges must be strongly held. In the end, Nepaul will be pacified by the influence of English settlement.

The Simla group of hill states is the district which presents the least promise of resources. Much of it consists of barren mountains and precipitous valleys, and, Simla being better known than the other Indian hill districts, an unfavourable opinion is formed by those acquainted with it, of the resources of the hills. The group is not however so unfavourable as is supposed.

In the Dhoon, as Sir Proby Cautley and Sir John Login have stated, there are lands capable of reclamation, and there are many places where the tea cultivation can be carried on, while the mineral productions are considerable. When the iron and other deposits of Kumaon are properly worked, the Simla group may not prove the least important of our hill territories. We have there clustered together a variety of countries of various geological constitution, and of various mineral productions, reaching from Gurhwal on the east, to Simla on the west.

It has been lately computed by an Indian authority, that, in the Himalayan districts, ranging from Munneepore round to Cashmere, there are sites for 50,000 tea-farms, each occupied by an English yeoman and his retainers. This is exclusive of tea-farms in other districts. Coffee-planting would likewise give great employment to English principals and assistants.

In a military point of view the Simla group is of value, not only as commanding the doabs on the upper Gangetic valley, which it can reach from their heads at periods when no march can be made across the swollen rivers, but, if rightly treated, it is one of the keys of our dominion.

In the Punjab government, we have to strengthen our hill garrisons so as to provide against any excesses of the tribes, to guard against any attempt from Affghanistan, and above all to protect our empire against Russia.

The most effective protection, next to an army of English troops, is a strong reserve in the hills. No one in former times could ever contemplate with satisfaction the prospect of meeting the armies of Russia on the frontiers of Central Asia, or even in the regions of the Punjab, with such troops as our late native army. For this defence alone, we ought to keep a strong English army in India, and with our settlements well held by militia and volunteers, every battalion and every battery could, by railway, be concentrated within a week on the north-western frontier.

To strengthen that frontier, we must occupy as settlements the up-countries of Kangra and Lahoul, and we must repair the mistake of alienating Cashmere, by giving its ruler an appanage elsewhere. With the resources of Cashmere turned to profit by an English population, we should have the mastery of the Punjab secured to us.

The subject is no novel, so vast, and so comprehensive in its details, that it cannot be treated completely in one memoir; it is only possible, briefly, to indicate some of the topics for investigation. Thus, there should be considered, the raising of short-service English hill corps to feed the immigration, the formation of canon foundries, gunpowder works, and small-arm factories, the employment of native corps and officers on the principle of highland regiments, the residence of officers' wives and families in the hills, the provision for English soldiers' wives and children in the hills, the greater encouragement of marriage among the soldiery, the grant of lands to veterans and invalids, the organization of corps of military pensioners, the foundation of local corps of volunteer artillery and riflemen, the increase of English militia in the cities of the plains, by the removal there of settlers from the hills, the strengthening of the police by retired soldiers trained in the native languages, the provision of employment on public works for soldiers in the hills, as set forth in the memorandum of Sir John Login, the removal of all soldiers' children from the plains to the hills, according to the recommendation of General Tremenheere; the arrangement of constant relief from the hills, of all troops detached in garrison in the plains.

The whole operation, it will be seen, will be to a great degree self-supporting. The military expenditure of India which is now disbursed in the plains, would in the hills form the most effective encouragement to settlers, by opening to them markets for their produce, as has been the effect at the Cape of Good Hope, in New Zealand, and elsewhere on a smaller scale.

APPENDIX.

Note on the Healthiness of the Bengal Stations.

Although the hill stations have, from the causes so well stated by Mr. Grant in the first volume of The Calcutta Medical Journal (Mr. A. Grant on Hill Diarrhœa and Dysentery), certainly failed to answer the great expectations formed of them, it is impossible from the numbers in the accompanying Table to arrive at any just conclusion as to their healthiness; for regiments are usually sent there after being decimated by sickness: and when, at the end of a year or two, the constitutions of the men

have somewhat rallied, the exigencies of the service require them to return to the plains, to make way for others, who have in turn been prostrated and rendered inefficient, by the fever and dysentery of Lahore or of Peshawur.

The Table tells its own tale; the different stations being given in the order of their healthiness, commencing with Rawul Pindee, which presents the lowest rate of mortality, and ending with Cawnpore, the place most fatal to our European soldiers. The lowest is $2\frac{3}{4}$ per cent., to $1\frac{3}{4}$, the average for infantry in the United Kingdom during the 10 years ending 1846, as stated by M. Boudin. The Punjab contains, it will be seen, in Rawul Pindee and Lahore * at once the healthiest and the least salubrious but one, of all our Bengal cantonments: and as connected with that country one cannot help remarking the enormous proportion of admissions to hospital at Peshawur, viz., 352 per cent of strength. This is owing to fever, the prevalence of which is probably due to three principal causes: to the proximity of a large jheel, and the numerous rivers in the Peshawur valley; to the great range of the thermometer at most seasons of the year, especially in the months of September and October; and to the severe duty required of the men.

Of the hill stations, Dugshai shows by far the smallest proportion of deaths—not quite 3 per cent. The average number at Kussowlee—$4\frac{1}{8}$—was just as great as at Meerut or Benares, which were indeed the healthiest of our old stations, while at Subathoo the ratio of deaths rose nearly 2 per cent. higher, or, to from $\frac{1}{2}$ to 1 per cent. above that of Agra, Chinsurah, or Dum Dum. After making all due allowance for the previous sickliness of the regiments sent there, it is evident that the site itself cannot be sufficiently elevated, or that there must be something faulty in the barracks, to account for the low place it holds in our list.

* The unhealthiness of Lahore is probably caused by the action of the sun (so peculiarly powerful in that country) upon the overflowings of the Ravee. Malaria is thus generated and borne by the wind in the direction of the cantonment.

TABLE

Intended to show the Comparative Healthiness (for European Troops) of the Principal Stations in the Bengal Establishment.

Stations.	Period of Observation.	Strength.	Treated.	Died.	Treated per 100 of strength.	Deaths per 100 of strength.
Rawul Pindee	6 years ending 1854-55	5,468	9,952	151	182·	2 76
Jullunder	9 ,, ,, 1854-55 *	7,163	11,731	205	163·77	2·86
Dugshai	5 ,, ,, 1854-55	4,227	7,494	126	177·28	2·98
Kussowlie	11 ,, ,, 1854-55 *	7,397	12,267	305	165·86	4·12
Meerut	9 ,, ,, 1852-53	15,915	33,038	766	207·59	4·12
Benares	9 ,, ,, 1852-5	1,372	3,053	58	222·	4·22
Agra	9 ,, ,, 1852-53 *	7,638	16,069	385	210·38	5·04
Chinsurah	26, 27 and 7 years ending 1837,†	6,531	9,288	332	141·29	5·08
Dum-Dum	9 years ending 1852-53 *	3,885	7,861	210	202·34	5·40
Subathoo	11 ,, ,, 1854-55 *	6,492	11,612	384	178·86	5·91
Umballah	11 ,, ,, 1854-55 *	19,137	37,342	1,162	195·12	6·07
Dinapore	9 ,, ,, 1852-53	8,733	16,510	542	189·	6·20
Ferozepore	11 ,, ,, 1854-55 *	8,918	19,399	566	217·51	6·34
Peshawur	6 ,, ,, 1854-55 *	14,867	52,321	269	351·92	6·51
Berhampore	1823 and 9 years ending 1834 †	11,077	22,156	763	200·01	6·88
Fort William	9 years ending 1852-55	6,426	12,049	450	187·50	7·
Lahore	9 ,, ,, 1854-55	15,289	41,861	1,153	273·79	7·54
Cawnpore	9 ,, ,, 1852-53	8,797	23,572	687	267·95	7·82

* Year 1849-50 not included.

† Col. Tulloch, quoted by Martin on Tropical Climates, p. 73.

Friday, February 4th, 1859.

Lieut.-Gen. Sir WILLIAM CODRINGTON, K.C.B., M.P., in the Chair.

ON THE ORDNANCE SURVEY.

By Colonel James, R.E., F.R.S., &c.

I am afraid you will find this a very dry subject, but I will endeavour to go rapidly over the various points, more with the view of giving a correct outline of the whole proceedings and history of the Survey, than of going into minute details, which would be more adapted for a book than a lecture.

The history of our Survey presents a most remarkable example of that gradual and slow developement of just views which we often witness on other questions in this country; and as there has been so much discussion, and so many changes in the orders which have been issued from time to time respecting it, I have gladly availed myself of this opportunity to explain to the Officers of the Army and Navy, and the public generally, the exact state of the question at the present moment.

The survey commenced under General Roy, R.E. in 1785; but the object then in view was simply the production of a military map on a 1-inch scale, and that survey, with considerable interruption, consequent upon the wars then going on, had extended in 1824 from the Land's End to the boundary of Yorkshire and Lancashire, including the whole of Wales. It was then decided that there should be a general valuation of Ireland, and that, as a necessary basis for that valuation, there should be a townland survey; Ireland being divided into smaller divisions of parishes than England, called townlands, which are generally co-extensive with private properties, averaging about 300 acres each.

The whole survey force was then sent to Ireland, and the survey of Great Britain was altogether suspended. We commenced first in the North of Ireland, I myself taking part in the survey. To obtain accurately the acreage of the townlands, which was at first supposed would be all that would be required, it was decided that the scale should be six inches to the mile; and then commenced that series of mistakes which has interfered with our proceedings up to the present day. For no sooner had we completed the survey of four counties, according to our instructions, than it was found that the skeleton plan, containing the mere boundary of the townlands and the principal roads and rivers, was altogether insufficient; and that every field and garden must be surveyed to enable the tenement valuation to be made. We had consequently again to proceed to the North and complete the survey, and we have hardly completed it yet, having to put in every single field through the northern counties of Ireland. Our parties are now finishing it—they are in Armagh, and have nearly completed that county; and, when that is finished, I trust it will close the six-inch survey of Ireland. But the mistake and

Engraved at the Ord. Map Office, Southampton.


Plate 1
Saxavord
Gerth of Scaw
Balta
SHETLAND ISLANDS
Foula
ORKNEY ISLANDS
Cowhythe
Gt. Stirling
Belhelvie Base
Ben Lomond
Kellie Law
Lumsden
Burleigh Moor
Easington
Holme Moss
Clifton Beacon
Delamere
Arbury Hill
Malvern
Cradle
Dunstable
Epping
Salisbury Base
G.S.O. Southampton
Black Down
Dunnose
Barrow Hill
Dunkirk
Geographical Miles

its consequences do not end there. Under the newly-constituted court, which was called the Encumbered Estates Court, and which is now called the Landed Estates Court, a vast amount of property is being constantly sold ; and for the purpose of sale they require accurate plans of the property. When you bear in mind that on the six-inch scale sixteen acres occupy one square inch only, you will understand how inadequately represented upon that scale were the small sub-divisions of property. By a curious coincidence, just as a royal commission on the survey had recommended the 25-inch scale for the survey of Great Britain, the judges of the Landed Estates Court in Ireland made an application, which has received the sanction of the Treasury, for the introduction of the 25-inch scale for Ireland, for the plans of all estates sold under the Landed Estates Court.

The survey of Ireland was completed on the six-inch scale; and, although it is to be regretted that it was not made in the first instance on a much larger scale, still it was found to be of such immense benefit as compared with the one-inch, that, when we resumed the survey of Great Britain in the North of England and South of Scotland, we were ordered to proceed upon the six-inch scale, as we had done in Ireland; and we completed the whole of Yorkshire and Lancashire, and several small counties in the South of Scotland on that scale. After we had completed Yorkshire and Lancashire, and several of the counties in Scotland, there commenced a discussion upon what was the proper scale for the plans, which, if it is quite closed, has only just been brought to a close ; a Royal commission, composed of many of the most distinguished men of the day, of which Lord Wrottesley, President of the Royal Society, was Chairman, having unanimously recommended the adoption of the 25-inch scale as the national scale for our cadastral survey.

With these preliminary observations, I may proceed to describe the operations of the survey itself. The first requisite for a survey is, of course, a triangulation. When I say a survey, I speak of the survey of a great kingdom, not of a limited district. It is absolutely necessary that you should have an accurate triangulation. And, as a preliminary to obtaining an accurate triangulation, you must have accurate bases measured.

Plate I. represents the triangulation which we have carried over the whole of the United Kingdom, from the Scilly Islands to the Shetland Islands. The bases that have been measured, and from which all the distances in that triangulation have been computed, were those on Salisbury Plain, at Lough Foyle in Ireland, Misterton Car in Nottinghamshire, Rhuddlan Marsh in the North of Wales, and Belhelvie in Aberdeenshire. The two first were measured with Colby's compensation bars, the others with steel chains 100 feet long. (Plate II. fig. 1.)

The compensation bars for the measurement of bases, which were designed by the late General Colby, are made in this way : a bar of brass, A B, is firmly connected to an iron bar, C D, at their centres ; these are again connected at each end with two iron tongues, E A, F B, moveable on pivots. On the projecting portions at E F a fine dot is made on a piece of platinum, and it is so arranged that the distance from the dot to the centre of the pivot at C shall be to the distance of the same dot to the

centre of the pivot at A in the ratio of the expansion or contraction of the iron bar C D, to the expansion or contraction of the brass bar A B. By this arrangement it will be seen that the distance between the dots at E and F remain at the uniform distance of 10 feet under every change of temperature.

These bars, in the actual measurement of the bases, are laid perfectly horizontal by means of levels, and ranged in a perfectly straight line by means of sights upon them, and a directing telescope.

To prevent any disturbance in the position of the first laid bar, when the next to be placed in its position is brought up, a double microscope (like an opera glass, the distance between the foci of which is exactly 6 inches) is placed on the end of the bar about to be laid in position; by this arrangement the first laid bars are never touched or disturbed, and the exact distance of 6 inches between the foci of the microscopes is preserved by compensation bars on the same principle as in the 10-foot bars.

Mr. Babbage and Sir John Herschel were present when upon Lough Foyle 500 feet of part of the base of seven miles were remeasured, and, testing it by the finest dot that was made with the point of a fine needle, it was found to be only the third of a dot in error; such was the extreme accuracy with which the operation was carried on.

It is of little consequence to obtain extreme accuracy in one portion of a work unless we obtain the same accuracy in every other portion. The horizontal angles of the triangulation, as well as the vertical angles and azimuthal bearings of the stations, were measured with theodolites 3 feet in diameter. These magnificent theodolites were made by the great Ramsden, who made one for the Royal Society and one for the Master-General of the Ordnance. They were the first instruments which measured the spherical excess. All the angles in the triangulation having been observed, we had to encounter a most formidable question, namely, the correction of the observed angles so as to render the triangulation perfectly consistent in itself; that is to say, so that the sum of the three angles in every triangle should be 180°, and the sum round every station 360°: to do that required a mass of calculation perfectly astounding; and, bold as the Russian engineers are in undertaking such questions, they were astonished when told that we had overcome the difficulty. The calculations which we had to make involved the solving of equations with thirty-six unknown quantities. For my part I have always considered *three* to be enough for a man with a moderate appetite for figures. The result of the triangulation has been this: By computing through the triangulation the length of one base from the other, and comparing the computed length with the measured distances, we found a difference of only 5 inches, the interval between Salisbury Plain and Lough Foyle being from 300 to 400 miles; and, when we compared the computed with the measured length of the base in Aberdeenshire, there was a difference of not more than 3 inches. Therefore we have a perfect moral certainty that we have a triangulation (which is the essential basis of accuracy) determined with a perfection which was never before attained.

We now come to another important point. It is also absolutely necessary that we should accurately determine the figure and dimensions of

Fig. 1.

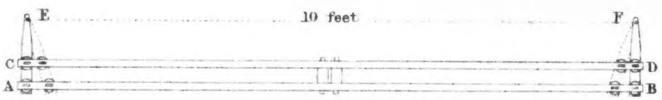

Fig. 2

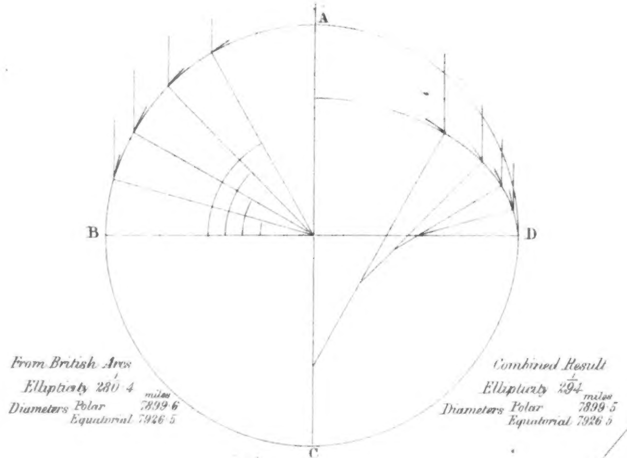

Fig. 3

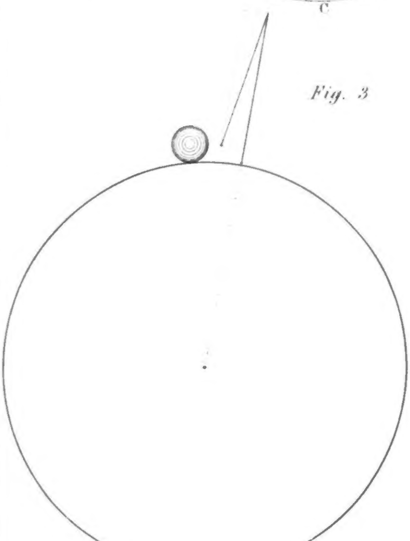

Fig. 4.

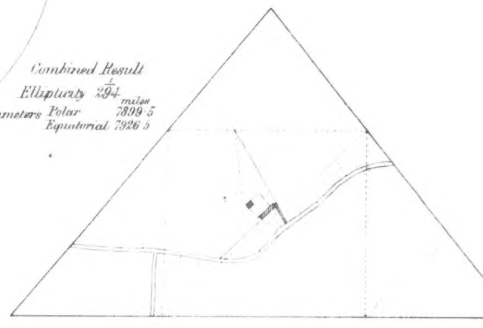

Fig. 7

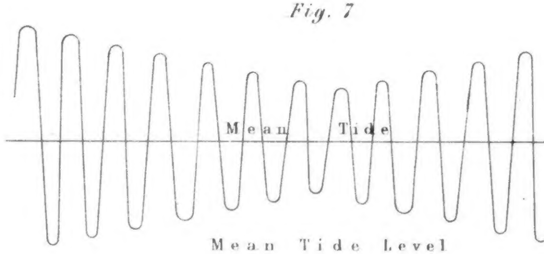

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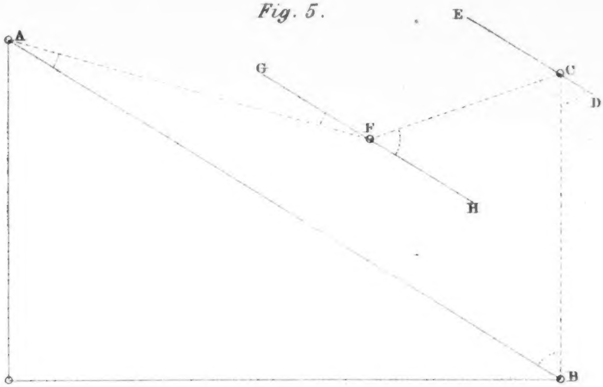
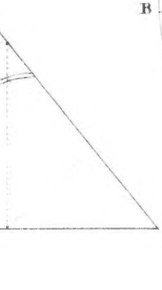
Fig. 5.





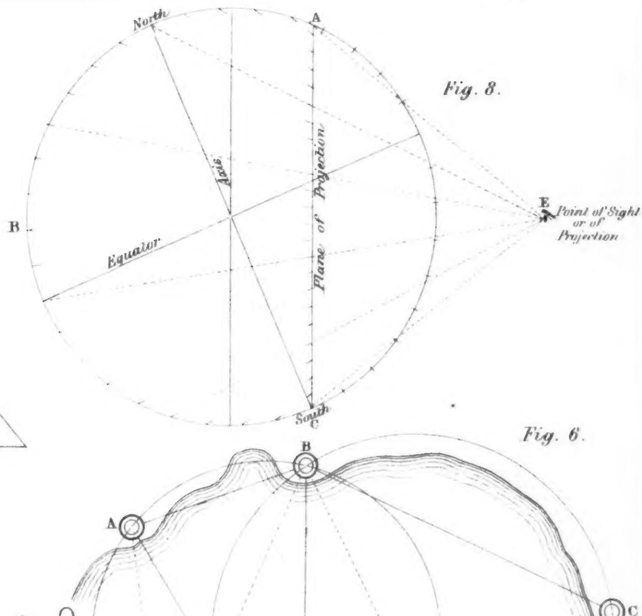
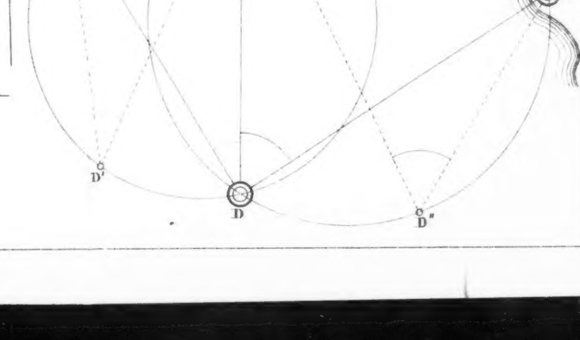
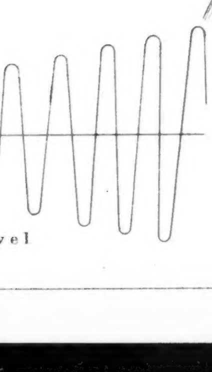


Fig. 8.

Fig. 6.





the earth. Suppose you have a globe that is scored over with meridians and parallels. If a triangulation like a network is placed over it, you will understand that, if the globe is either too large or too small, the points of the angles will not reach their required latitudes and longitudes; and therefore it is absolutely necessary, in extensive surveys, that we should get a perfect knowledge of the figure and dimensions of the earth. From our own series of triangles we computed the 10 degrees between the Shetlands and the Isle of Wight. If we multiply that by 36, we get the circumference of the globe, supposing the earth to be a perfect sphere. If it were a perfect sphere, every degree of latitude along a meridian would be of equal length. But we find, if we measure a degree of latitude in the South of England, and another near Edinburgh, and another in the Shetland Islands, the degree is 100 yards longer at Edinburgh than at Southampton, and 200 yards longer in the Shetlands; this is caused by the ellipticity of the earth or the flattening at the poles. (Plate II. fig. 2.)

On the diagram (fig. A, B, C,) is the section of a perfect sphere, and the distances increase uniformly with the latitudes. But on the other side of the diagram, A, D, C, is the section of an elipsoid, and you will see that the distances for equal latitudes increase towards the poles; by the law of this increase we are able to determine the nature of the curve that is followed. The earth has an ellipticity of $\frac{1}{294}$, the polar diameter of the earth being 7899·5 miles, and the equatorial diameter being 7926·5. In this investigation we meet with a great difficulty, arising from the local attraction of the mountains which surround the stations at which the observations are taken. If for instance we take points north and south of Arthur's Seat, the attraction of the mountain would draw in the plumb-line towards it. This is made sensible by the levels attached to the instrument, the observed difference of latitude between the two stations being greater than is due to the distance along the meridian. Having eliminated the errors arising from this cause, we can determine the true figure of the earth, and we also obtain the data for determining the density of the earth, we can find the specific gravity of the mountain, and we know that the force of its attraction is in proportion to the mass, and in the inverse ratio of the square of the distance. So again the attraction of the earth itself is in proportion to its mass, and in the inverse ratio of the square of the radius. The ratio of these two attractions gives us the tangent of the angle of deflection in the plumb-line. If you suppose the mass of Arthur's Seat to be in the form of a small globe (Plate II. fig. 3), whilst this large globe represents the earth, then the plumb line, instead of going straight to the centre of the earth, will be drawn in the direction of the smaller globe. The result of this investigation is, that the attraction of the mountain was found to be about one-half only of what it would have been if it was of the same specific gravity as the earth, and that, the specific gravity of the mountain being 2·75, the specific gravity or mean density of the earth is 5·316.

The larger triangulation, the sides of which are about 100 miles long, having been established, it was subdivided into smaller triangles of about 10 or 15 miles a side. The triangulation being completed, the "detailed survey" is commenced. In the organisation of the survey, the work is

divided into several branches of which the triangulation which I have been describing forms the first; then follows the levelling, then the detailed survey, which I am about to refer to, then the preparation of the manuscript plans, and their final publication.

The whole survey force is 1,500 men, in which four companies of the Royal Engineers are employed, forming a military nucleus which keeps all in order. This force is divided into sections for each branch of the work. In fact, we carry out the subdivision of labour to as full an extent as a manufacturer would in any other department of work, and we find great benefit to arise from this system. We find also that we can now advantageously, and at a great reduction of cost, introduce the system of piece-work, and we have recourse to it wherever the nature of the work admits of its adoption.

I speak in the presence of many gentlemen in the Army and Navy who are familiar with the ordinary modes of surveying, and to whom it is unnecessary to describe many things I am about to refer to. But, as the sailors say, to keep the convoy together we must regulate our rate of going by the slowest ship. The system of survey which we prefer, when practicable, is to give a man a triangle, or half-a-dozen triangles; he chains along the sides of each triangle, leaving piquets upon the lines as he proceeds in such positions as he thinks most convenient for taking the detail of the survey. Our reason for this is, that, having computed the distances from our base line, we know, to the fraction of an inch, what the length of each side is, and when we see the field-book brought in, we can tell whether the chaining of the three sides is accurate, and when we lay down the work on the plan, it will be seen that the cross lines will not fit into their places, unless they are also of the exact dimensions that they should be. Therefore, although we do not watch the proceedings of the surveyor, we have a most thorough check upon the quality as well as the quantity of his work. (Plate II. fig. 4.)

This mode of surveying, viz. by chaining all the sides of the triangles, and a great number of internal lines, all connected with the sides, is the method we employ for the survey of the cultivated districts. The method we employ in the uncultivated districts, and which we must employ in the highlands, where it would be impossible to chain the sides of the triangles in the way I have described, is what is called traverse surveying.

In surveying by traverses along the course of streams or roads, the theodolite is employed, and is first put up at one of the trigonometrical stations, and one of the sides of the triangle is taken as a meridian to work from. (Plate II. fig. 5.)

The theodolite being placed in the direction of the meridian, B A, the bearing of the first station, C, in the traverse is observed; then clamping the instrument, and chaining the line B C, set up the instrument again at C, with the plates clamped, and after clamping the underplate, release the upper and take the next forward angle to F, and so on through the whole traverse. By following this course, the bearings are always taken in reference to the direction of the line taken as the first meridian, because the first observed angle, A B C, is equal to the angle B C D, in which position the instrument has been placed at C, and the line E D is parallel to the line A B, from which we started. A similar system will be pursued

at all the other stations, and when the traverse is closed at A, the angle B A F, if no mistake has been made, will be equal to the last observed angle A F G. The surveyor, therefore, has the means himself of knowing whether any error has been made in the angles during the course of the traverse.

Another mode of checking the work, and which enables us to say in what part of a traverse any error may have been made, is analogous to that adopted by sailors for fixing the position of any object near the coast. If he has three points, as A B C, (Plate II. fig. 6,) determined on land, by taking the two angles which A B, B C subtend from a boat at D, he fixes his position, because there is only the point D where the two circumscribing circles intersect each other, from which they could have been observed. By taking the bearing of the trigonometrical station, the traverse surveyor fixes his position in like manner, and provides checks for his work as it proceeds.

I will next refer to the levels. The datum level assumed for the survey is that of mean tide. (Plate II. fig. 7.) The tides, from high spring tides, continue to descend from day to day, till they come down to neap tide, again rising to spring tides; thus oscillating daily above and below the level of mean tide, which is the datum which we take, and all our levels are referred to that point. We take tidal observations at a great number of places all round the coast, and level along from one to the other; we thus establish a series of levels, which again become points of reference for branch lines of levels in every direction. These again become the initial points from which contours can be set off, and the data obtained for making a model. An ordinary survey gives the plane surface of the ground only, but a contoured plan gives the data for a model, for it gives us the relief also.

Having described our methods of surveying, we must refer to the series of maps which the Royal Commissioners have recommended the Government to adopt, and which, subject to the approval of Parliament, we are ordered to go on with. For towns we have the large survey on the one five hundredth scale, 500 feet being represented by 1 foot, or 42 feet by 1 inch.

For the parishes we have the 25-inch scale, which has been so much discussed. The 25-inch scale, which is equal to 1 square inch to an acre, is limited to the cultivated districts.

For the uncultivated districts of the counties, the scale is 6 inches to the mile, the 25-inch plans of the cultivated districts being reduced to the 6-inch scale, so as to complete the counties on one uniform scale.

We again reduce the 6-inch plans to the 1-inch scale, to form the ordinary 1-inch map. Therefore, for certain portions of the country we have four scales. One great object in having this series of plans is to carry into effect that great measure which I believe to be most important for the agricultural and commercial interests of this country, namely, the facilitating the transfer of property. It is a question which, as I see by Her Majesty's speech from the Throne, is now at the commencement of this session to be taken up by the Government.

I propose now to explain the manner in which we make the reductions of the plans by photography. Having that series of maps to make which

I have described, it would be the most tedious and expensive thing imaginable, having the large plans upon the 25-inch scale, again to replot the 25-inch to form the 6-inch, and again to replot the 6-inch to the 1-inch, it being at the same time necessary that everything should be represented accurately. Seeing the enormous amount of labour involved by the whole process of reduction by the pentagraph, I directed my attention to the possibility of getting some other method; and, although I was at first discouraged by the photographers whom I consulted, I have now entirely succeeded by means of photography, and I may say with absolute accuracy; for a commission, of which Sir Roderick Murchison was chairman, has investigated the subject, and it is stated in the report that the greatest error is the one four hundredth part of an inch; therefore, practically, we may consider the reduction as being absolutely correct. In making the reductions we use the ordinary collodion process. [*Several of the negatives were here exhibited, as well as a great number of positive impressions which were produced from them.*] In some instances several sheets have been joined together, and by the manner in which they join, it was evident that they were perfectly accurate, for if they were not so, the lines would not correspond. The success which we have achieved is, perhaps, more important as a question of time than of money; for the question was, how it was to be done at all, so as to get out the maps in any reasonable time; we now find that by the aid of photography we can strike off any number that may be required in a short time, and without the slightest difficulty. With regard to the saving of money, it saves us at the present moment, in wages merely, upwards of £1,600 a year; and if the survey should be continued on the large scale, it would save £32,000, or not less than £40,000 in all.

The next thing was to introduce an expeditious mode of publishing the plans on a large scale. We first tried the system of lithography, but we eventually determined to try zincography. In the first place, the lithographic stones were enormously expensive; secondly, they were of tremendous weight, being several hundredweight to lift; and, what was still worse, when they had cost us £4 or £5 they frequently broke. We therefore determined to try zincography. In that attempt we have succeeded beyond all expectation; and I take no credit to myself for it, because I have been assisted by intelligent non-commissioned officers and others who carry out one's ideas in a manner most gratifying to me as superintendent. [*A small press was here exhibited to show how the operation was performed.*]

Colonel James then proceeded: I should have explained before, that Corporal Neil has placed in the press a thin piece of tracing paper, which is laid over a plan and traced; all the figures referring to the fields, the acreage of which is given, are put in by mechanical means; not only is that done upon the tracing, but it is also done upon that which may be called the manuscript map. We have electrotyped the stamps, and the result is, that when the plans come in from parties stationed in different places, as at Perth, Newcastle, and Carlisle, for instance, you cannot tell one from the other—Corporal Neil has one of those tracings. You will see in a short time that he will produce a plate: the impressions will

not be quite perfect at first, but if you want 500 they will improve as they go on.

After we have reduced the plans by photography, it is necessary to engrave the 6-inch sheets upon copper. It is so arranged that 16 of the reductions exactly cover the area of one of the sheets of the 6-inch survey, and therefore the reductions can be brought into their exact positions by placing the tracings from them over the marginal lines and trigonometrical stations as drawn upon the copper plate. The engraved work is cut into the plate; but we have introduced a great number of mechanical contrivances, as for making the letters, stamps for the trees, and ruling machines for the tints, and so on, which economizes the labour of engraving; the result is, that we produce the plates from which the impressions are taken as you now see them, and at a very much diminished cost as compared to what it was formerly.

We now come to the sketching of the ground. We take the 6-inch impressions and put them into the hands of the field-parties to sketch the ground on. It was useless labour to make a reduced copy in manuscript when we had the engraved plan which we could give the men, and therefore we use the engraved impression. The ground having been sketched by the field-sketchers, as we term them, a drawing from the field sketch is next made on an outline impression on the 1-inch scale, and from that is engraved the 1-inch map which the public receive. You will observe the necessity of having the intermediate hill drawing, which requires a very first-rate artist to draw: this is a step which we should be very glad indeed to get rid of, and I have had a great number of experiments made with a view of effecting that object, and to get a copy by photography of the original sketches, straight down upon the plates, without the intervention of that drawing. I have here four experimental sheets intended to be sent to India, and I think we have in that trial sheet alone a pretty good proof that we shall succeed.

Any gentlemen who have examined the old sheets of the map of England must have observed how very much the plates have been worn in printing, and it has been a source to us of constant expense, and I may say of shame, to be continually repairing our plates and giving to the public very damaged and bad impressions. We now get rid of the whole of that difficulty. As soon as an original plate—of Edinburgh for example—is engraved, we put it in the electrotype battery (Smee's battery). Upon that original engraved plate we throw down by the battery a plate which is called the "matrix," and which is therefore in relief, and then again we throw down another plate upon the matrix which is the exact duplicate of the original plate; and so, for the mere expenditure of zinc and acid, we are enabled to produce any number of exact duplicates of the original plate. It is impossible to exaggerate the advantage which this has been to us. In the first place Sir Roderick Murchison, for example, requires a special map for his geological survey, and we take a plate for geology, leaving our original plate untouched. Again, we require indexes to the counties, examples of which are on the wall, and we take another plate for them. The indexes to the survey are by counties, whilst the engraving of the

1-inch map is by rectangular sheets. To make the indexes, we simply cut out those portions of several matrixes which would form one county. These several parts are then put together, and the electrotype copy taken, we are thus enabled to bring out the county map, which is a most beautiful engraving, and yet the hand of man has never touched it.

The accuracy with which these duplicates, made by the electrotype process, are made, and the manner in which the metal finds its way into every crevice of the engraving, is to me one of the most wonderful things I know of, and the more I contemplate it, the more astonished I am; if you take a microscope and compare the duplicate and the original, not the slightest difference can be discovered between the two. But still more astonishing is the process called acierizing, by which a steel surface is put on the copper duplicate, the object being to prevent the wearing away of the plate under the printing operation. We have examined the impressions from the acierized duplicates, and we cannot, even with the microscope, find any difference between them and the original. When we consider how extremely minute the particles or atoms of metal must be, to produce such a result, it is quite wonderful.

I think I have given you an outline of nearly all of our operations. It could only be an outline in the time allowed for a lecture of this kind; but I trust it will be sufficient to shew you that the survey has assumed a character altogether different to that from which it started, and altogether different to that which it had assumed in the south of England. Our large-scale plans have been hitherto confined to the north of England and to Scotland. And when we hear gentleman saying that this large scale is an abominable Scotch job, I may remark that we had done a great deal more in England than in Scotland on the large scales. We have never made any distinction between the surveys of England and Scotland; it was the survey of *Great Britain* which was going on. We have now large parties stationed in Cumberland and in Northumberland, and we shall have made great progress in those two counties by the end of this year, so that we shall shortly be able to close the gap which now exists between the surveys of England and Scotland.

With regard to the estimates for this work, we have this most surprising result from the different changes which we have made in the mode of conducting the work, and the introduction of all those mechanical appliances which I have attempted to describe. We have reduced the estimate made by my predecessor, and which is published in the correspondence upon the survey in a Parliamentary Paper, and find that the actual cost (for it is not an estimate any longer) is less than one-half the cost at which it was originally estimated. It was estimated by Colonel Hall at 2*s.* an acre, and we have reduced it to 11½*d.*, but I will stick to 1*s.* to provide for contingencies. The difference of the cost, however, is such, that upon the average annual expenditure upon the survey, it is equivalent to an annual saving of £60,000.

I have concluded the observations which I think it necessary to make with reference to the Ordnance Survey, but I have been requested by the Council of this Society to explain the nature of the projection of the sphere which I have made, and I shall be happy to do so, because it is likely to become a very useful one, especially when we want to embrace

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GEOMETRICAL PR

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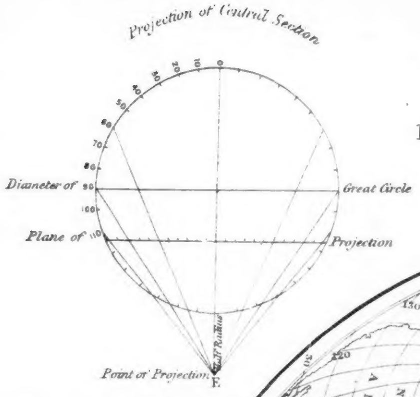
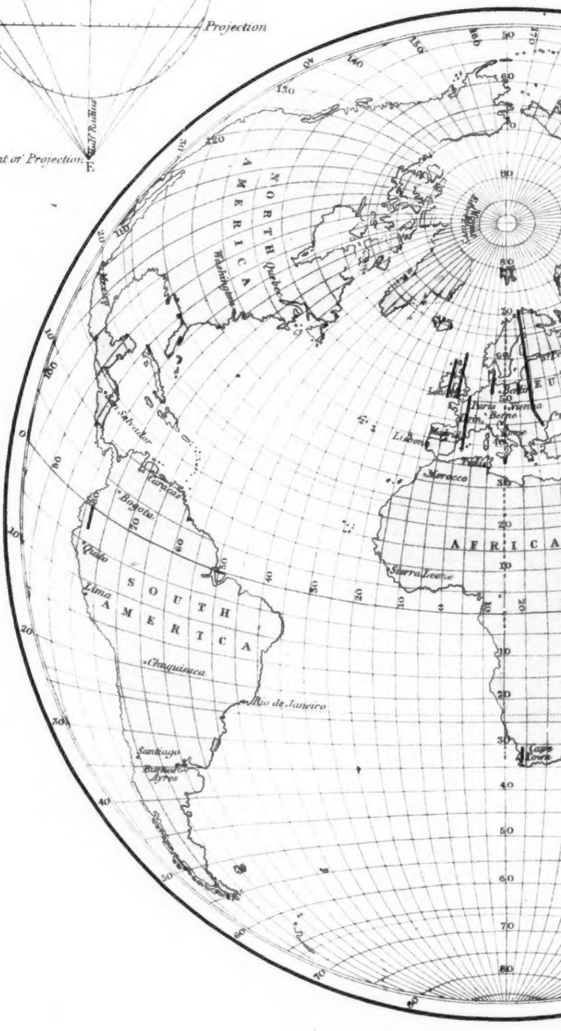
TWO THIRDS OF T

BY

Lieut^{t} Colonel H. James, R.E

Superintendent of the Or





ENGRAVED AT THE ORDNANCE MAP

1857

FROM A REDUCTION MADE BY

Note — *The point of projection is in the axis of a great circl*
and 23° 30′ North Latitude and at the distance
surface of the sphere. The plane of projection
at the distance of 23° 30′ from it towards the poin
therefore embraces 227° of a great circle, and c
than ⅔ of the surface of the sphere. The he
Hipparchus 200 years before Christ, but this is t
projection of more than a hemisphere has been

N.B. The dark lines indicate the position of all the

TRICAL PROJECTION

OF

RDS OF THE SPHERE

BY

H. James, R.E. F.R.S. M.R.I.A. &c.

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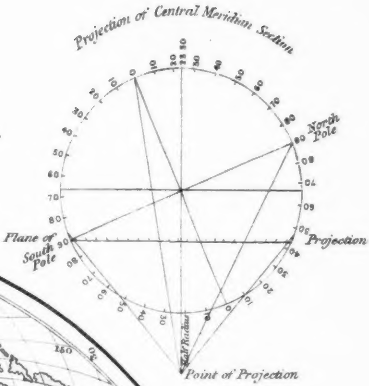

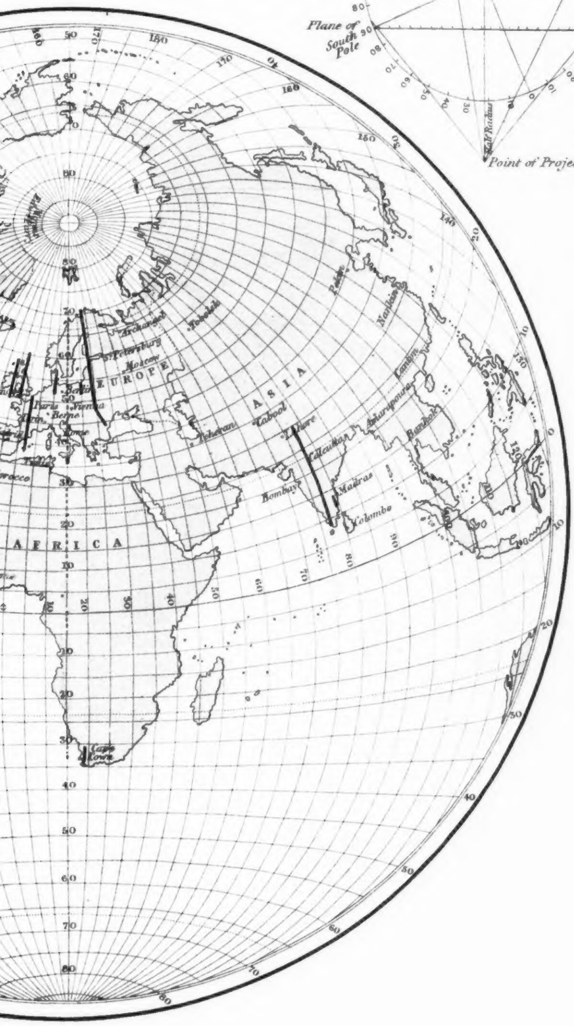

RDNANCE MAP OFFICE SOUTHAMPTON

1857

CTION MADE BY PHOTOGRAPHY

is of a great circle whose pole is in 15° E. Longitude at the distance of half the radius above the ane of projection is parallel to this great circle towards the point of projection. The projection eat circle, and consequently $\frac{7}{10}$ or rather more ere. The hemisphere was first projected by rist, but this is the first time that a Geometrical phere has been made.

ition of all the measured arcs of Meridians.

a large portion of the earth's surface at one view. The geometrical projection of the hemisphere, which is known as the stereographic (the earliest known projection of the hemisphere) was made by Hipparchus 200 years before the birth of Christ; but it is a curious circumstance that up to the present time it seems not to have occurred to any one to make a geometrical projection of more than a hemisphere. It is remarked by Sir John Herschel in his Outlines of Astronomy, that Falmouth is the centre of the hemisphere which embraces the greatest amount of land and the great centre therefore of men. In verifying this fact on a globe it occurred to me to inquire what would be the centre of all the land, and I found that a point in 15° east longitude and 23° 30′ north latitude, was the centre of a circle embracing Europe, Asia, Africa, America, and a part of Australia, including two-thirds of the surface of the sphere. The question was, how that could be represented. It seemed like an impossibility to do so, but it occurred to me that the difficulty might be got over by imagining we were looking into the sphere and not at it. The projection is made in this manner; the eye or point of projection E is at the distance of half the radius from the sphere, A B C is two-thirds of the sphere, and A C the plane of projection, on which from the point E all the interior surface of A B C would be seen. (Plate II. fig. 8.)

By adopting the position shown for the axis of the earth, I get the north pole or the south pole, as it may be, at the limit of the projection. Many gentlemen who have seen these projections, and Sir Charles Lyell and others, have said that it is the first time they ever thoroughly understood the relation of one part of the earth to the other, for you cannot see it by looking at a globe or at Mercator's projection; and if you attempt to get it from the two hemispheres, your eye is thrown out, and you cannot comprehend it; but in this projection (Plate III.) you get everything round the poles, and you see the accurate relation of one part to another. Upon this projection I have laid down what are called the lines of equal magnetic declination, and you will see how all those lines converge upon the magnetic pole, and upon the true pole of the earth. I have a similar projection for the southern regions and the Pacific Ocean; and we have also applied it to the projection of the stars. In this latter case it is essentially like looking into the vault of the heavens; and instead of a representation by six separate plates, as you have in Sir John Lubbock's gnomonic projection, you have two-thirds of the sphere represented at once. This projection is also particularly well suited for the representation of the isothermal and isobarometrical lines for exhibiting the direction of the winds and currents, and, as I have before said, all the great physical facts for the comprehension and exhibition of which we require to have before us the greater portion of the earth.

[*Corporal Neil struck off, during the lecture, some impressions from a zinc plate, which were exhibited, and which are now deposited in the topographical department of the Institution.*]

This mode of preparing a plate for printing is exactly the reverse of the engraving process. In engraving the engraver cuts into the copper, and the ink is rubbed in previous to taking the impression; but in this process the tracing of the plan, traced with greasy ink, is laid on the zinc; the grease of the ink coming in contact with the surface of the zinc

adheres to it; a very weak solution of gallic and phosphoric acids is then applied, which acts upon the exposed part of the plate, while the oil of the ink preserves the plate where there is any writing or drawing. The effect is that the bitten portion will not receive the ink, and the unbitten or greasy surface will, as in lithography.

You see the importance of having a simple, expeditious, and inexpensive mode of producing this 25-inch map, by which it is brought home, so to speak, to the door of every man, for little more than the value of the paper. We are able to strike the impressions off at the rate of 1,000 a day; and everybody buys when they can be got so cheaply. The Government does not seek to make a profit out of them; the survey has been paid for in the taxes; and therefore it lets the people have the copies as cheaply as possible. I advocated this strongly before the Committee of the House of Commons on the survey, though a great number of gentlemen said "No; make the survey and lock it up." The advantage of this process is, that it is so cheap that the sale of the maps covers the entire cost of the publication. And I will close my observations by saying that, whatever may be the case in other things, the public in this matter get their money's worth for their money.

Chairman.—Before we part, our thanks are due to Colonel James for his lecture. Instead of its having been a dry one, it has been very much the contrary. The subject is one which is becoming more and more important to financial as well as to military people. And I beg to tender our very cordial thanks to Colonel James.

ON THE IMPORTANCE OF A KNOWLEDGE OF THE ELEMENTS OF PRACTICAL SURGERY TO NAVAL AND MILITARY OFFICERS.

By William Henry Flower, F.R.C.S., Assistant-Surgeon to the Middlesex Hospital, formerly of H.M.'s 63rd Regiment.

One of the numerous branches into which the art of warfare is divided, has for its immediate object the destruction of human life, or, as it may more correctly and perhaps more humanely be defined, the infliction of such injuries as shall disable from further service. This terrible art has certainly held no backward place amid the onward progress which has characterised all departments of human skill and knowledge. Every successive war, nay, almost every year of peace, has added its quota of progress: even within this century, the general increase of the weight and force of the projectiles employed, especially the substitution of the heavy conical rifle bullet for the small round musket ball of the peninsular campaign, has added greatly to the severity and danger of the wounds received in battle.

With this resistless onward progress of the destroyer there has been marching side by side, less obtrusively it is true, but not less surely, a companion art, whose only mission is to alleviate the sufferings and lessen the devastation caused by the other. Almost paradoxical as it may appear, from the time that man first waged war upon, and begun to wound and kill his fellow-men, he has been ready to avail himself of all the knowledge and skill that could be obtained to save and to cure.

We are not, however, at present so much concerned with what may be done by those who are professionally engaged in the practice of surgery, as with what may sometimes be accomplished in the same direction by others.

Addresses have been occasionally given at this Institution upon the advantages of a knowledge of nearly every branch of science known to man, and I think that it is now generally admitted that the more varied and extensive any one's knowledge is the greater will be his powers of application to any particular science, and the greater will be his means of promoting his own happiness and that of mankind in general. This is especially applicable to those occupying the position of most of the members of this Institution, frequently led by their professional duties to situations remote from the resources and enjoyments, cares and distractions of busy life, but still surrounded with food for study and contemplation in the ever present and yet ever interesting, ever instructive works of nature. On these grounds alone the science of surgery in all its branches direct and collateral, including anatomy, which teaches the structure, and physiology, which treats of the functions and actions of the component parts of that wondrous work of God, the human frame, cannot be without interest to every mind endowed with powers of observation and reflection.

But setting such considerations aside for the present, and looking upon

the subject only in its more practical bearings upon the ordinary business of life, it is my purpose to show that there are cases in which, by a little knowledge rightly applied, something may be done towards alleviating the effects of those injuries to which all, but especially those who follow the honourable but dangerous professions of the soldier or sailor, are liable.

But here at the outset a timely warning must be given, that if any one with asmattering of knowledge were to think that he could replace the regularly-educated physician or surgeon, such knowledge would, indeed, be a dangerous thing. To a bystander it may seem a simple matter to dress a wound or set a broken leg, and the best of medical practice may be full of guesses and blunders and uncertainties, painful and humiliating to human reason; but yet many years of labour, reading, observation, and reflection are required to arrive at any tolerable amount of knowledge of this, which I may safely say is one of the most intricate branches of human study. Little indeed, painfully, miserably little, as is our knowledge of and power over disease, when measured by what the imagination would soar to or the heart desire, yet this little raises the educated medical man, when on his own ground, to an immeasurable distance above one who has never passed through the ordeal of a professional education, and places a bar between them which it would be folly to attempt to leap over. There is an amount of knowledge to be obtained by all which will never bring its votaries to this, but on the contrary teach them more fully to value and to appreciate, where they would never hope to supersede.

With the judiciously increased medical staff of both services, and the more general employment of surgeons on ships, in colonies, and rura districts, it can rarely happen now that proper aid cannot be obtainel before an illness is of any long duration; but, either in the peacefud occupations of exploring or surveying parties, or in the more dangerousl duties of skirmishing and foraging on land, or the gunboat service at sea, accidents happen in which early assistance is of momentous consequence. In such cases the immediate presence of a surgeon can rarely be procured; the poor sufferer placed, perhaps, by the carelessness or ignorance of those around him, in a position of agonizing pain, receives irreparable injury; it may be that his life's blood ebbs away for want of assistance, which it would be in the power of any of his comrades to render, if they had but a little previous instruction. Another important consideration is the satisfaction of not feeling hopelessly lost, of knowing something of the extent of the danger, and that such help as may be obtained is always at hand. The assurance that the presence of a surgeon gives, even where surrounding circumstances render his assistance of very little real value (as I had frequent opportunities of observing in the trenches before Sebastopol), is no mean thing; and the same confidence would doubtless prevail to a great extent, if men who were known to be capable of acting as surgeons in cases of sudden emergence, were to be found in every detachment of combatants, however small.

There will scarcely be time in the limits of this lecture to do more than glance briefly at the principal injuries which may be met with on such services as officers and men in the army and navy are liable to perform, and which may be relieved by prompt assistance from any tolerably skilful and sensible person. It is not intended to touch upon any but

accidents requiring *surgical* treatment; and it must be remembered that all that is said only applies to cases where no surgeon is at hand, and must not interfere with seeking his assistance.

It is well known that, whenever a wound is inflicted on almost any part of the body, bleeding, or as it is called in technical language, hæmorrhage, ensues. If this bleeding is of small amount, but little harm will come to the sufferer; but if, on the other hand, it be in very large quantity, or long continued, it will be the direct cause of the injured person's death. Hence, it has always been one of the first duties of those engaged in the treatment of wounds, to be familiar with the effects of, and also the means of preventing, loss of blood.

In order to render what follows intelligible, it will be necessary to make a brief physiological explanation. The blood, as most people are aware, is sent from the heart to every part of the body, through a system of tubes called arteries : a main artery runs down each limb, and gives off branches, which further sub-divide until they become a set of minute vessels called capillaries, invisible to the naked eye, pervading every tissue of the body in a most delicate network ; these finally collect again into another set of vessels called veins, which, uniting together, end in the two main trunks which bring the blood back to the heart. We have then three sets of vessels from which bleeding may take place: first, the arteries, bringing blood direct from the heart, and which, when cut across, allow it to escape in a forcible stream, often spouting to a distance of several feet, and in a succession of jerks, corresponding to the successive impulses of the heart's action; secondly, the minute capillaries, of which hundreds are divided in every wound, and from which the escape is a mere general oozing of the cut surface; thirdly, the veins, in which the blood, darker in colour, and changed in properties, has lost the vigorous impulse derived from the heart, and runs slowly, so that a steady, but comparatively feeble stream, easily stayed by slight pressure, flows from a wounded vein. These are facts of great simplicity, a knowledge of which every one interested in the economy of the human body may readily acquire, but which are of the highest practical importance in the treatment of accidental hæmorrhage. From them we learn that it is not so much from the veins, nor from the capillary vessels, nor even from the smaller arterial twigs, but only when a considerable sized artery is divided, that we may anticipate severe and rapid bleeding, such as is likely to prove the immediate cause of death unless prompt assistance is at hand.

I believe that, as it was at one time the opinion among surgeons, it is still the impression among others, that loss of blood is the effect most to be dreaded, of wounds received upon battle-fields. But the more accurate observations of recent times, and an increased acquaintance with the natural processes by which bleeding is often arrested before life is extinct, even in extensive wounds, have led to a considerable modification of this idea. In fact, deaths arising from this cause are not very numerous, except in cases where some important part of the trunk, or some very large vessel is opened, in which case the blood would be so rapidly lost that scarcely any assistance would be of avail. The reasons that gunshot wounds of the extremities bleed less than almost any other kind of injury that can be inflicted upon them are curious, and depend upon some peculiar

properties with which arteries are endowed, apparently for protective purposes. One of these properties is great elasticity, which causes them to slip out of the way of a ball, instead of being wounded by it. Bullets may traverse a limb without injuring the great vessels, though apparently passing exactly through their course. Again, in wounds of a very different nature, those made by round shot or pieces of shell, extremely frequent upon the battle-field, the arteries are not cut, but torn across; and it is well known to surgeons that, when this happens, there is usually but little hæmorrhage. The fact is well known; its explanation would require more time than can be allowed in the limits of this lecture. Instances not unfrequently occur (I can recall several within my own experience) in which a limb is carried entirely away, leaving a ragged stump. The end of the great artery may be seen rising in the wound at each pulsation of the heart, but not a drop of blood issues from it, owing to the remarkable process by which, in such wounds, nature closes the breach almost as soon as it is made. Persons who have received such injuries usually die, not from loss of blood, but from the shock to the system, producing an amount of depression greater than the vital powers are able to sustain. If a wound so extensive were inflicted by the clean cut of a knife, blood would flow so rapidly that life would be extinct in a few minutes.

I mention these facts to show that the alarm that has been felt upon this subject, both by surgeons and wounded men, may to a great extent be set aside; but as there are undoubtedly cases in which bleeding does take place so freely as to endanger life, both in the above-named and other kinds of accidents, I will proceed to enumerate the readiest means for arresting it, which will be in the power of any one to adopt. In the first place, simple attention to position, the part being, if possible, raised above the level of the rest of the body, is a thing which should never be lost sight of. In carrying a wounded man to the rear, it may be useful to bear this in mind. One of the most efficient agents in repressing hæmorrhage is cold; it causes the open mouths of the little bleeding arteries to contract, and so prevents the escape of their contents. How frequently is it the practice to cover up wounds with soft warm dressings, to put on bandage after bandage, in the vain hope of staying the flow of the vital fluid; no treatment could be worse. Take away all the coverings, expose the wound freely to the air, or pour a stream of water as cold as can be procured upon it, and the work is done. Of the various substances employed mechanically or chemically to stop bleeding, known by the general name of styptics, I need say nothing here, as they are not of general application, and, except in hospitals, rarely at hand if wanted immediately. The same remark will apply to that most powerful agent the "actual cautery," or heated iron. For all slight cases the simple methods above mentioned will suffice. If an arterial trunk of any size is wounded and bleeding, nothing but the "ligature" of the vessel will make an effectual cure. This is done by seizing the cut end of the artery with the forceps or tentaculum (a sharp hook for the purpose), drawing it a little way from the surface of the wound, and tying a piece of silk firmly round it. This proceeding can of course hardly be expected from any non-professional person, but fortunately the same result can be

temporarily obtained by any method which compresses the artery, so as to obstruct the flow of blood through it, applied either at or above the wounded part. If this should be near to the heart, in the neck for instance, the bleeding point must be pressed upon with the fingers, and kept closed until assistance shall arrive. Should the vessel wounded be very large, and the hæmorrhage profuse, of course the means used must be proportionally prompt and effective. Baron Larrey * relates the case of an aid-de-camp to General Berthier, who at the siege of St. Jean d'Acre received a bullet wound in the neck which opened the main artery, the carotid. One of the gunners, a very intelligent man, immediately seized it with his fingers, and kept the wound closed until the surgeon arrived, and the officer's life was saved. Had there been any hesitation on the part of that soldier the result must have been different. Somewhat similar instances are narrated as having occurred in our own armies in India, by Hennen † and Cole.‡

When the wound is in one of the limbs, it will generally be more convenient to apply the pressure at some part of the extremity nearer to the *heart* than the wound, so as to cut off the flow of blood towards it. As has already been mentioned, a principal vessel runs down each limb, but there are also smaller communicating branches which keep up what is called "collateral circulation," so that even if the main pipe is obstructed or obliterated all nutrition of the extremity does not cease. Our object in applying a tourniquet is generally sufficiently accomplished if we can stop the flow of blood in the main trunk. Now as this vessel lies tolerably deep, and most of the returning venous channels are nearer to the surface, a simple bandage fastened round the limb, without any regard for the anatomical position of the parts, will be more likely to do harm than good, not arresting the flow towards the wound, but impeding its return from it, acting in fact just as the tape bound round the arm does in the operation of blood-letting. Hence, in every form of tourniquet that has been invented, or in the extemporized arrangements for effecting its purpose in the field, the great point aimed at has been to concentrate the pressure upon one particular spot, that where the artery runs, relieving it as much as possible from other parts. This object is effected by means of the *pad*, which, together with the *band* for encircling the limb, and the *means of tightening*, constitute the essential parts of the instrument. To know exactly the best points to apply the tourniquet requires a slight acquaintance with anatomy, but not more than any one may very readily acquire. It may be sufficient for the present purpose to indicate the inner side of the arm, about midway between the shoulder and elbow, and the inner side of the front of the thigh, about three or four inches from the top, as the best positions for the pad, as in these parts the bone, being beneath the artery, gives a firm support against which it may be compressed. The exact situation, which varies slightly in different persons, can always be ascertained by feeling for the pulsation of the vessel. The degree of pressure required is to be measured by the cessation of the bleeding, and of all pulsation in the arteries of the limb below the constricted part; and it must be remembered that the tightening process should only be con-

* Mémoires de Chirurgie Militaire, vol. i. p. 309.

† Hennen's Military Surgery, p. 180. ‡ Cole's Military Surgery, p. 121.

tinued till this effect ensues. If any unnecessary force is employed the soft parts of the limb may be severely bruised. As Hennen justly remarks, "Too great caution cannot be employed in guarding against superfluous and long-continued pressure, and the attendants, as well as the wounded individuals, should be warned to apply as soon as possible to the medical assistants, in order that they may examine the state of parts in which the circulation is confined."

The earliest form of this instrument in use is that called the "Stick Tourniquet," (fig. 1), said to have been invented by Morrell, at the siege of Besançon, in 1674. As it fully answers its purpose, can be made of materials almost always at hand, may be variously modified according to circumstances, and can be very readily applied, it is the one best adapted for emergencies. It consists of a band of webbing (a pocket handkerchief, brace, or scarf, will do as well,) (fig. 2) with a stuffed leather pad; in default of which, a pebble wrapped up in a handkerchief, or a cork, or any similar substance, will answer the purpose. The band is placed round the limb, and tied in an ordinary double knot, the pad being over the artery, while, for the sake of convenience in fastening, the knot is usually made on the opposite or outer side of the limb. Then a stout piece of stick, or anything else that comes to hand, the ramrod of a pistol, or a drumstick for instance, is passed through the knot, and turned several times round, by which means the band may be tightened as much as is required, and the pad pressed down upon the artery. One thing more is wanting to prevent the twisting of the knot hurting the skin over which it is placed. This was accomplished in Morrell's tourniquet by an oblong piece of leather, with slits cut near each extremity, through which the ends of the band were passed, the middle of the leather being interposed between the knot and the skin. In an extempore instrument, a piece of paper folded (fig. 2)

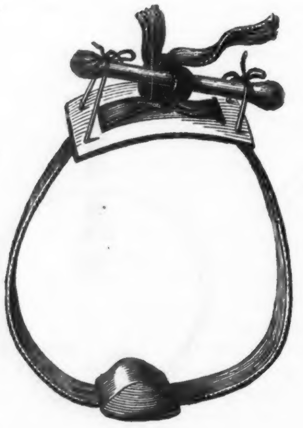

Fig. 1.

Fig. 2.

and placed under the knot will answer as well. When the stick has been twisted round sufficiently, it must be secured, to prevent its turning back and loosening the band. This is easily done by tying it with a little piece of twne or tape, or with the ends of the handkerchief, or whatever it is that encircles the limb.

Such instruments as these were in common use in our navy during the great war, especially for gun-boat service, the stick for fastening them, called a "toggle," being usually made by the ship's carpenter; it was a piece of tough wood, four or five inches long, and in each end, which was a little thicker than the middle (see fig. 2), a hole was drilled, through which a piece of twine could be passed, and made fast to the band that encircled the leg, or sometimes a tape attached to the leather was used to secure the end of the stick (fig. 1).

In the "field tourniquet" supplied to the army during the Crimean campaign, the band (a piece of webbing about two feet long and an inch and a quarter broad) was passed over two brass rollers, turning in a little frame, to the under surface of which the pad was attached; this being adjusted over the artery, the ends of the band were pulled as tight as possible and fixed by means of three spikes on each side of the frame. This instrument occupies very little space in packing; its disadvantage is that pulling by the hand is not always sufficiently powerful to produce the requisite degree of pressure, the "toggle" being in this respect far superior, and in most that were made the pad was much too small, at least for the thigh.

The "screw" tourniquet (fig. 3), now furnished with all regulation cases of surgical instruments, both to the army and navy, was invented by

Fig. 3.

Fig. 4.

Petit in the beginning of the last century, and is on the whole one of the most portable and efficient instruments of the kind. It consists of a band of webbing fastened on to the limb by a buckle, a pad, and an apparatus for tightening, formed of two plates of brass connected by a screw. The band is passed through the plates in such a manner that, as they are separated by the action of the screw, it becomes proportionally tightened. The general principle is the same as Morrell's, the main difference being the substitution of the screw in place of the knot and stick as the constricting force. There is a very convenient modification of this tourniquet invented by Dr. Malan, in which the screw, instead of projecting at right angles from the limb, lies flat upon it, and hence when adjusted is less in the way, and not so likely to be accidentally displaced.

The objection to all of the above-described kinds of tourniquets is, that the band which surrounds the limb presses tightly upon it in every part, and so obstructs the backward flow of blood in the veins. To remedy this, instruments have been invented in which the pressure is confined to two spots—one over the artery, and the other on the opposite side of the limb. The most common of these is the "ring" tourniquet (fig. 4), consisting, as its name implies, of a ring of metal, with a large concave pad for the outer side of the limb to rest against, and a smaller pad for the artery, fixed to the end of a screw which works through the ring. When it is adjusted upon the part, the latter pad is pressed down upon the artery by turning the screw. Although these undoubtedly answer the requirements of a tourniquet better than those in which a band is used; yet their size and inconvenient form, and their liability to get displaced unless constantly watched, render them unfitted for field practice, where convenience and portability are essentials.

Among the endless variety of tourniquets that have been invented, I have thought it worth while to describe these few as assisting to illustrate the principle upon which the simplest form of the instrument is used. To apply even this effectually a little judgment and some slight anatomical and surgical knowledge is necessary. It will not be sufficient to serve out a number of them to any particular part of a ship's company or a regiment, without very special directions as to their use. The steadiest and ablest hands—those in whom the other men will have confidence—should be selected for this service, and receive practical instructions in it directly from their surgeon. If tourniquets are worth having at all—and that they have occasionally been the means of saving life no one will deny—it is surely worth while to take the pains necessary to apply them in such a manner as to effect the purpose for which they are designed.

Another accident to which we are all liable, especially when engaged upon dangerous services, is breaking some of our bones. In order to understand all that is necessary for the purpose of treating "fractures," as they are technically called, an extensive acquaintance with anatomy and surgery is necessary—far more than can be expected from any non-professional person; but still there is much that should be known, and that thoroughly well, by all who are exposed to these injuries, where immediate surgical aid cannot be obtained. "Such accidents, severe and painful in themselves, are often rendered more serious and agonising by the awkward and careless manner in which, with the very best intentions

of those who afford assistance, the sufferer is carried with his limb dangling or rolling about to the nearest medical man." * Great and often irreparable injury is thus inflicted; a *simple* fracture—that is, one in which the bone is merely snapped across without any external wound—is often converted, by the sharp broken end being allowed to press through the flesh, into what is called *compound:* the former merely requiring a few weeks' rest to make an effectual cure, the latter often entailing months of suffering, sometimes causing the loss, or permanent impairment of the limb, and not unfrequently terminating in the death of the patient.

The first portion of the treatment of a fracture has such an important effect upon the ultimate result, that it is the duty of every one who by any combination of circumstances may be called on to practise it, to pay some attention to this subject; and the removal of wounded or otherwise injured persons to where surgical aid can be obtained very often falls to the lot of non-medical officers. In the first place, it is desirable to be able to discover whether a leg or an arm is broken. In ordinary cases this is not difficult—the patient is unable to lift up the limb, and in any attempt to do so by himself or others an unnatural bending and motion are seen at the broken part. If there is any doubt, too much care of course is better than too little. While seeking for surgical assistance, if the injury is in the upper extremity, simply slinging the arm in the position most comfortable, usually with the elbow bent at right-angles across the chest, will be sufficient, and a broad handkerchief, generally at hand, makes the most efficient sling. As fractures of the leg are generally attended with more danger, more care will be required in their management. If the patient has to be moved, be it ever so short a distance, he must be placed upon some sort of stretcher; if a proper one is not to be found, a shutter, hurdle, or an extempore one made by tying wooden poles, oars, or branches of trees together, with a piece of sheeting or blanket stretched over them, will do. The side poles of the stretcher should always be kept apart by traverses or cross-bars fixed near each end, otherwise the weight of the patient will cause him to hang in a very unfavourable position, and bring the poles together to the great inconvenience of the persons carrying them. A man with a broken leg should lie on a surface perfectly flat, and which will not yield to his weight. If there is any distance to go, it is as well to have two persons at each end, all of course keeping step. Hand-carriage in this way is always preferable to any other mode of conveyance, especially in rough countries, where the jolting of a waggon or cart is often insufferable.

Having placed the person on the stretcher, the limb must be laid as nearly as possible in its natural direction; for if the broken part be left bent, it is far from improbable that one or other of the ends of the bone will be thrust through the skin, and a compound fracture be produced. In order to avoid this, it is best to bring the sound limb alongside the broken one, and tie them together with two or three bandages or handkerchiefs; this will give great support, and prevent any movement in it. If further security seems desirable, splints should also be fastened to the

* Household Surgery, or Hints in Emergencies. By J. F. South.

sides of the limb, and nothing will answer this purpose better than those made of straw, a material perhaps more frequently at hand than any other ; a bundle about the thickness of the wrist, and of the required length, is bound together by a piece of cord wound tightly round it. The splint thus made is remarkably firm and light.

Major-General Sir Michael Creagh has informed me of a plan for carrying wounded men, which under some circumstances might be very useful. A single pole eight or nine feet in length, branch of tree, oar, or anything of the sort that can be procured, is laid down beside him, and the man lashed firmly to it from head to foot with handkerchiefs, belts, clothes, or blankets torn into strips, &c.; it is then lifted up and carried on the shoulders of two men, or may even be dragged for some distance with one end resting on the ground by a single man. Rough as this contrivance seems, it has been on several occasions the means of saving life.

Bones, instead of being broken, are sometimes dislocated or put out of joint. It is of great importance that this injury should be remedied as early as possible after its occurrence; even within a few hours the contraction of the muscles becomes so powerful as to render the reduction of the bone difficult; if left several weeks it is often impossible. Dislocations are recognised by the alteration in the shape of the joint, with impaired motion, and pain, and by a change in the direction of the bone. They happen far more frequently in the shoulder than any other joint, as a person in falling down usually puts out his arms to save his face, and throws the whole weight of his body upon this part. There are several methods of reducing this dislocation; one of the readiest is to make the patient lie down either on a couch or the ground, then sit down beside him, placing one of your heels (of course unbooted) into his armpit, grasp his arm firmly a little above the wrist and pull until you feel the bone go back into its place with a little jerk, then cease the extension, bring the arm to the side with the elbow bent, and by means of a bandage keep it at perfect rest for several weeks, otherwise it will be apt to become again displaced.

I would mention as other points that might be attended to, especially by those travelling in remote regions, the treatment of the different kinds of wounds, whether incised, punctured, lacerated, &c., and also of bruises and sprains. In all these injuries the simpler the mode of cure the better; nearly all the balsams, ointments, plasters, and medicated dressings that have been invented are of little more value than were the charms and incantations used by our forefathers. All that is required for most wounds is a piece of wet lint, covered with oiled silk or thin gutta percha to keep it moist, and changed as often as cleanliness requires. Plain water is really the "sovereign'st thing on earth" in these cases.

Burns, scalds, and more particularly frostbite, are accidents frequently met with, and in which much mischief may be done by improper management at the beginning. The same principle of treatment must be adopted in injuries arising from excessive heat as in those caused by intense cold, but exactly reversed; in the one case cooling must be brought about gradually, all the early applications being warm; in the other, cold appliances only can be allowed at first, the reaction being produced but very

slowly. If a frostbitten part is suddenly brought near the fire it will almost certainly be destroyed; whereas if the circulation is gradually restored by rubbing first with snow or cold water, and increasing the temperature by degrees, it may be saved.

Wounds received from venemous animals, especially snakes, produce their injurious effects so rapidly, that no time should be lost in treating them. To prevent the absorption of the poison a bandage should be tied tightly round the limb above the bitten part, so as to obstruct the return of blood to the heart, and the wound may be cut out, or burnt with a hot iron, while the great constitutional depression that usually follows should be combated by the free and early administration of the most powerful stimulants, as ammonia, brandy, &c. It would be highly interesting and often useful to travellers if they were to learn what venomous animals existed in the country they were about to visit, and how they might be distinguished from the harmless species.

The treatment of persons apparently drowned, though not strictly surgical, is a subject of great interest, far too extensive, however, to be entered into, upon the present occasion.

It is not within the scope of this lecture, nor would it be possible in many lectures, to *teach* even the elements of surgery. I can only indicate the above as subjects which appear worthy of particular attention. A practical knowledge of them is the only one of real value. The sight of a few such injuries properly treated would be the best means of gaining this. Any one about to travel into remote regions, could not do better than attend for a few months at the out-patient department of a large hospital, where all the minor accidents are daily treated in such numbers as to afford in a short time specimens of every variety. Of course such an undertaking would not be necessary to officers in the ordinary circumstances of the service, who are now seldom far from the assistance of well-educated surgeons; but even with them a little reading and thought bestowed upon the subject, and a little conversation with, and instruction from, their own medical officer, may be the means of affording in some unexpected moment valuable aid to a suffering fellow-creature.

Wednesday, March 23d, 1859.

The Right Hon. the EARL OF ELLENBOROUGH, G.C.B., in the Chair.

ON THE FINANCIAL AND EXECUTIVE ADMINISTRATION OF THE BRITISH INDIAN EMPIRE.*

By Lieut.-Col. J. P. Kennedy,

Formerly an Officer of the Royal Engineers, Military Secretary to the late General Sir C. Napier when Commander in Chief in India, and Consulting Engineer to the Supreme Government in India for the Railway Department.

1. More than a year has elapsed since I had the honour of addressing the members of this Institution on the subject now under review.

That period has brought forth events as creditable to the character of the British Empire as they promise to be promotive of its broadest interests.

2. We have witnessed the transfer of British rule in India to the direct and responsible authority of a single Minister of Her Majesty's Government; and the intelligible exposition just offered to Parliament, by this first responsible Minister for India, *is a hopeful earnest of prospective benefit from the change so long and earnestly invoked.*

3. We find that social order has succeeded to the anarchy which for a time existed in India, and that, in the process of this change, not only has *a ferocious army of mutineers been overthrown*, but a host of bilious lecturers upon "human deterioration," and "the wane of British power," been practically answered.

4. It has been proved that a culminating point of moral and physical excellence characterizes the British people of the present day; *for the annals of the world do not offer another ordeal so searching* as that by which our countrymen have been triumphantly tested in their long Indian struggle.

A struggle not confined to our glorious soldiers and their prescient and gallant leaders, but unflinchingly sustained by all our race there, *without restriction* to profession, sex, or age! Assuredly, so long as a nation is peopled by such a race *it must be invincible* and progressive! A faithful record of British resistance to the Indian mutineers will offer the brightest page in history, as proving the most *indomitable perseverance, courage, and*

* In consequence of the very great importance of this Paper at the present juncture, and the high interest taken in all matters connected with the future peace and security of the Indian Empire, and the organization of the Indian Army, the Council have considered it expedient to print Colonel Kennedy's Lecture out of its regular course, in order that it may be sooner brought before the public.

fortitude of which the human race has shown itself capable under such unexampled and protracted difficulties; whilst, on the other side, in analysing the producing causes of the events, it must exhibit the most dismal picture of those disasters which nations undergo from an irresponsible and improvident administration of public affairs.

Finance.

5. The object of my former address was to stimulate the application of a remedy for the past omission to furnish the Indian territories, at the fitting times, with the first essentials of civilization,—*the means of intercourse and transport.* I sought to prove that this grave omission was *ruinous to the public finances*, obstructive to industry, trade, and commerce; impedimental to the administration of justice, education, police, as to all other civil objects of State superintendence; and, finally, HAZARDOUS to the English inhabitants, to our military reputation, and to British power, by the difficulties that were thus left opposed to the concentration of the limited number of European troops so thinly scattered throughout that enormous and populous Empire.

6. These propositions were broadly stated in principle, so far as relates to the financial question, by Her Majesty's Secretary of State for India in his lucid exposition made to the House of Commons on the 14th of last February (1859).

He shows the revenue of India to be about £32,000,000, under four principal heads, viz.:—

1. Land Rent, about	£19,000,000,	or 60 per cent. of the whole.
2. Opium .	6,000,000,	„ 20 „
3. Salt and Customs	4,300,000.	
4. Miscellaneous	3,000,000.	

He shows that the expenditure of the two years 1857-8 and 1858-9 left an actual deficit of £21,600,000, wholly attributable to the Insurrection.

He gives the military expenditure of 1856-7, as an average year prior to the Mutiny, at . . . £11,546,000
Do. 1857-8, first year of Mutiny . 18,212,000
Do. 1858-9, second do. . . 22,598,000*

Finally, he shows for the last two years an average annual revenue deficiency of about £9,000,000.

7. In speaking of the Land Rent, which he describes as contributing 60 per cent. of the entire revenue, he says, "and we must therefore consider this branch of the revenue *as being comparatively inelastic. The increase* of which it is capable arises principally from two causes. One cause of increase, which has been very active in times past, but of which we may hope there will be no more just at present, is addition to the British territory, and consequent increase of the area over which the tax is levied. *The other cause is the taking into cultivation of lands hitherto*

* The rupee is calculated here at 2s.

waste. THAT PROCESS IS LIKELY CONSIDERABLY TO *increase, as Railways, and other means of communication,* open up the interior of the country; and we have therefore, in its results, a probable source of GREAT WEALTH at some future time."

8. The second large item of revenue, derived from Opium, one-fifth of the whole, he considers, for excellent reasons assigned, as fluctuating and precarious.

The Salt Tax he defines as in effect a poll tax.

9. Having gone through the general subjects of revenue and expenditure he makes the following statement:

"*If we can hardly hope for any great augmentation of Indian revenue, nor any large reduction of Indian expenditure, the problem of Indian finance is reduced to this: How to keep, in future years, the military expenditure within its former limits.*"

10. "The British Army in India is now only one portion of the entire army of England. When telegraph communication is complete, with the facilities which steam is giving every day, it is obvious that the distance is lessened, and that our whole resources are in a position to be brought to bear on any Indian disturbance much more rapidly than before. So again in *India itself the great system of railway communication,* to which I shall presently advert, which at present is only commenced, will in a short time bring together the entire peninsula, and the troops there will then be efficient in many quarters almost simultaneously."

11. Here, then, we have the high authority of the Secretary of State for India admitting that his chief dependence *for increasing the revenue of that country is an extension of railway intercourse,* as the means by which waste lands are to be made productive. And in like manner that his *hope of reducing expenditure is nearly limited to* a diminution of the military establishment, *which* the extension of railways will enable, by bringing together the entire peninsula, *so that the troops there will then be efficient in many quarters almost simultaneously.*

12. This brings the question of Indian Finance within the following narrow limits. That an annual deficit in the revenue must be provided for by loans until a sufficient quantity of railway shall have been constructed to admit of a large reduction in the military force.

This inevitable fact I brought before the Institution a year since, *in the hope of stimulating railway construction.*

The head of the Government having taken the same view, we may confidently hope that a vigorous course of construction will now be made to replace the dilatory progress which has hitherto been the rule.

13. The effect of rapid railway construction in tending to bring the public expenditure within the revenue may be measured as follows:

Assuming that the gross number of the forces, and the ratio of British to Native troops, as stated in the latest Return, prior to 14th Feb. 1859, were what the Government consider safe and fitted to the existing circumstances of India, viz.:

Europeans.	Natives.	Total Troops.
91,590	243,956	335,546.

And assuming, *also, that the acknowledged defects in the Police Force shall have been thoroughly corrected, I consider that the Government can reduce* 346

British and 1616 *Native troops for every* 100 *additional miles of railway which shall be opened for traffic, until the army shall have been brought down to a permanent establishment of* 50,000 *British and* 50,000 *Native troops*, keeping the Artillery, Engineers, and Sappers, all British.

14. We are now in the Spring of 1859, and the process MAY be completed as follows, taking the present cost of the army to be £14,000,000, and its strength 91,590 Europeans, and 243,956 Natives.

	Miles of Railway opened.	Troops Reduced.		Troops Remaining.		Army Cost.	
		British.	Native.	British.	Native.	Reduced.	Remaining.
1860	2,000	6,920	32,320	84,670	211,636	1,210,601	12,789,399
1861	4,000	6,920	32,320	77,750	179,316	1,210,601	11,578,798
1862	6,000	6,920	32,320	70,830	146,996	1,210,601	10,368,197
1863	8,000	6,920	32,320	63,910	114,676	1,210,601	9,157,596
1864	10,000	6,920	32,320	56,990	82,356	1,210,601	7,946,995
1865	12,000	6,920	32,320	50,070	50,036	1,210,601	6,736,394
		41,520	193,920	100,106		7,263,606	
		235,440				£14,000,000	
		335,546 men					

If this course can be pursued, in six years the army expenditure may be reduced progressively till it reaches a gross reduction at the end of that time over £7,000,000, leaving the permanent cost something below that annual amount.

15. If it be argued that 2,000 miles of railway per annum are more than can be opened in India, the simple answer is, that a much more rapid rate of progress was accomplished in America, with *iron materials principally, and capital to a considerable extent supplied from England*, and without any approach to the urgent need that should now stimulate our progress in India. *What Americans* HAVE DONE, *Englishmen* CAN DO! The railway mileage opened in America was, in 1848, 932 *miles*; in 1849, 1258 *miles*; in 1850, 1506 *miles*; in 1851, 2022 *miles*; in 1852, 2437 *miles*; in 1853, 2196 *miles*; in 1854, 3927 *miles*; in 1855, 2009 *miles*; in 1856, 2841 *miles!* In those nine years the aggregate value of iron carried from England to the United States was £27,155,152—from England to the East Indies *only* £3,840,230. In 1857 it was ascertained that an aggregate of 26,000 miles of railway had been opened in America from the commencement in 1830! whilst up to 1857 only 358 miles had been opened in India; and the mileage open there at the present time is but 559 miles.

16. In my former address to this Institution I stated, "that the construction of a sufficient portion of well selected lines of railway, say 12,000 miles, at a cost of £72,000,000 (which may be accomplished in six years), will admit of a reduction in the numerical strength of the Indian armies of occupation from 325,000 men to 100,000, with a cor-

responding reduction of military expenditure from over £13,000,000 to £6,000,000 annually; and will convert an annual revenue deficiency of £5,000,000 into a surplus of £2,000,000. 2nd. They will likewise enable a force of 50,000 men to be concentrated to any given point of any railway, from a distributed army of *only* 100,000 men, *costing only* £6,000,000 annually, IN ONE-SEVENTH OF THE TIME required to concentrate, *by marching*, an equal force from a similarly distributed army of 325,050 *men*, costing £13,000,000 annually."

We find, from the experience of the past year, that the excess of expenditure over revenue, and wholly attributable to the military establishment and charges caused by the Mutinies, has largely exceeded what I had anticipated; and hence, *the importance of the principle urged as a remedy*, and ADMITTED BY THE BEST AUTHORITY TO BE THE RIGHT REMEDY, *becomes the more urgent.*

IRRIGATION.

17. The financial subject next to be considered is that of Irrigation; which, after the opening up of railways or other intercourse, is undoubtedly the most important question of territorial improvement and finance. It is certainly *second* to railways, because the additional produce which it enables the land to yield would be of no value unless the requisite means of communication and transport be previously in existence, *by which it can be conveyed to market;* and this axiom holds good in reference to every other description of produce which that vast empire can be made to yield.

18. The Secretary of State has exhibited the enormous profits which the Government have actually derived from irrigation.

That of the *Cooleroon*, in the Madras Presidency, opened in 1836-7, at a cost of £21,700, he states to have given an average net yearly profit for sixteen years of £27,700, or about 120 per cent. per annum. That of the *Godavery*, in the Madras Presidency, opened in 1852-3, at a cost of £203,000, he states to have produced an increased revenue of £44,000, or over 20 per cent.

The Fordack Canal, in Scinde, he states cost £2,700, and paid £5,000, nearly 200 per cent. in the first year; another paid 58 per cent. of its cost in the first year; and a third, which cost £3,600, produced £5,000, nearly 150 per cent. in the first twelve months; yet with all these palpable proofs of the certainty by which irrigation investments, *effected by Government*, on their own fee property, can be made to relieve the embarrassed Public Revenue of the State, we find that a portion of this valuable birthright, to the extent of £1,000,000, has been assigned to a private Company in Madras, giving besides a guarantee of 5 per cent. upon the million of capital thus to be expended!

19. Taking the profits realised by the Government themselves at only 40 per cent. upon the investments, which is palpably below the real average, this transaction amounts to their having assumed the *entire risk* of the enterprise, whilst they have relinquished the prospect of enormous gain, and given away the opportunity of realising £400,000 a-year, with a certain large annual deficit of revenue to be provided for!!!

20. This was not a good financial arrangement, yet it was precisely

what has been done to the extent of about £30,000,000 of capital in the railway investments! *The true principle of finance is, where a party assumes all the* RISK, *that he should likewise appropriate the profits, and make his arrangements accordingly for executing the undertaking through his own agency.* The Government have much greater facilities for making good arrangements in those matters than private companies.

21. The boards of direction of companies, however fitted for deliberative investigation, are necessarily the most unsuccessful class of administrators that has yet been placed to direct any executive operation. This fact has been proved, *even to a proverb*, in English joint stock companies.

22. Irrigation in India is a fitting subject for Government investment on their own account, and to a large extent. If they think fit to invest £10,000,000 on that account, within a moderate period and on sound principles, they may fairly expect to realise 40 per cent. annually; which would enable them to wipe away the salt monopoly, justly defined by the Secretary of State as a poll tax. It is not only a poll tax, but a monopoly which shuts out from general commercial use one of the most important articles in nature.

23. It is true that the Indian Empire has been handed over to Her Majesty's Government in a most lamentable condition, with—

First. A native army of 100,000 men in revolt, and undergoing the process of annihilation;

Second. A disorganized police force of 600,000 men, whose practice, as described by the highest Government authorities, is rather to outrage than protect the laws and the people;

Third. A most harassing system for the administration of justice in the criminal and superior civil courts;

Fourth. A territory teeming with products, *which cannot be reached by commerce, capital, or industry*, owing to the absence of roads of intercourse;

Fifth. The remuneration of the labourer only 3*d*. per day;

Sixth. A public expenditure which must exceed the revenue, although happily in a decreasing ratio, for two or three years to come.

24. Here we have undoubtedly *a murky political horizon*, but there is one ray so bright shining through it as to give the statesman not only a hope, but certainty, that the gloom is but temporary, and must rapidly pass away.

25. Whatever may have been the results in other respects, it were an unfair omission to pass in silence one most important financial principle of the former Rulers which redounds to their honour as administrators of Indian affairs,—one for which both the British and the Indian people must acknowledge their lasting obligations,—one also which the practice of England and nearly every other country would have justified them in withholding—

They did not alienate from the state its public property!!

They did not give to private individuals the fee of the land, which now yields a legitimate revenue amounting to nearly four-fifths of the entire state income, including that class of produce, opium, which they reserved the exclusive right to cultivate.

26. Had the fee of the land been handed over in large estates to feudal proprietors in India, it would have been sub-let to occupiers at probably

much higher rents than are now required by the state. The rent would have become, as at present, a charge upon the produce, and an equal additional amount must have been levied in taxes upon the industry of the country to meet the Government expenditure. Every sound political economist must therefore see that it has saved the necessity of imposing burdens on the people to its own amount without pressing upon any occupier, or on the produce of the land, in a way which it would not have pressed, and perhaps much more heavily, had it been given in large fee grants to private proprietors.

27. The Indian system properly executed offers vast public benefits, but it entails in its administration vast additional duties and responsibilities. It concentrates under one authority the functions of the most important classes in civilized life,—the legislative and executive direction of public affairs; the detailed administration of the entire landed property of the country; and those comprehensive developments of wealth and industry emanating from the class of capitalists first created by the accumulations of rent.

28. The task of Indian administration is truly Herculean. It has to regulate by sound forethought and timely action, not only the public affairs of the empire but the individual industrial proceedings of its 130 millions of subjects. As this concentrated power *wisely directed* would offer the most rapid and effectual opportunity of conferring general benefits, so must its omissions be in proportion fatal. There are no secondary means by which such omissions can be supplied or their consequences mitigated. Yet the Indian administration could scarcely have divided its responsibilities, or restricted its existing powers, without producing even greater evils than those that exist. The requirements are becoming daily more palpable, the desire to apply the fitting remedies more general and intense.

The organic changes which have already taken place will give the best security for sound administrative action in future. We may now look forward to that full development of industry so urgently called for, that, under the circumstances of India, it amounts to the most stringent administrative obligation; an obligation, however, which there should be no disinclination, on the contrary a strong desire, to fulfil, because it has already been shown that the required investments, if judiciously conducted, must return enormous profits for their outlay.

Had the administrators of Indian affairs taken this view of their position at an early date, the condition and public finances of their empire would at the present day offer a reality far beyond the imaginings of the most enthusiastic political economists.

Conceive the Indian Government on their own account to have commenced and kept pace with the Americans in railway construction from the year 1830; to have executed on their own account, at about £6,000 per mile, 12,000 miles of line, giving a net return of 8 per cent.; to have commenced at the same date a judicious investment of £10,000,000 on irrigation works, giving them a return of 40 per cent.; finally, to have been sustained by the credit of the British Government in borrowing the money thus required at 3½ per cent.,—they would have been able to offer such a balance sheet as follows:—

PUBLIC INCOME.

	£	£
1. Permanent Revenue.		
Land Rent as returned in 1856-7	16,604,282	
Opium do. 1857-8	5,865,718	
Subsidies from Native States do.	507,804	
Post Office as returned in do.	177,706	
Electric Telegraph do. do.	22,108	
Marine & Pilotage do. 1856-7	161,488	
Judicial Receipts do. do.	191,834	
Sale of Presents do. do.	18,452	
Revenue from Prince Edward's Island 1857-8	119,766	
Do. " Courg " 1856-7	19,013	
Interest on Debts due by Native States do.	60,506	
Toll and Ferry Collection do.	62,225	
Mint Receipts do.	246,000	
Miscellaneous Receipts, Revenue Dept. do.	151,723	
Small Farms, Madras do.	12,330	
Miscellaneous Receipts, Civil and Political Dept. 1856-7	72,862	24,293,817
2. Taxes, temporary, till they can be removed.		
Salt, exclusive of Custom Duty on Salt imported, 1856-7	2,517,726	
Excise Duties in Calcutta do.	42,829	
Customs do.	1,961,759	
Stamp Duties do.	583,280	
Sugar do.	382,921	
Abkarra do.	859,131	
Maturpha, Madras do.	101,642	6,449,288
Total present Income		30,743,105
3. *Permanent Revenue Estimated to accrue from Investment.*		
Additional Land Rent to be expected from opening Railways	5,000,000	
Irrigation Investment of £10,000,000 return at 40 per cent.	4,000,000	
Railway do. £72,000,000 do. 8 do.	5,760,000	14,760,000
		£45,503,105

TOTAL EXPENDITURE

	£	£
For 1856-7, or former normal Rate	29,846,451	
Less saving to be expected on Military charges by the effect of Railways when constructed as enabling a reduction of the Army in comparison with the establishment of 1856-7	3,756,714	26,089,737
Annual Balance, which would be applicable to liquidation of debt already contracted, and of further funds to be raised for revenue deficiencies of next 3 years, and for funds to be invested in Railways and Irrigation, say total debt £180,000,000, to be liquidated by annual surplus revenue in about 12 years		19,413,368
		£45,503,105

Note.—In this Statement the Rupee is calculated at 1*s.* 10½*d.*

In the preceding financial view I have classified the public income under two general heads—Revenue and Taxes.

Revenue in the sense here meant may be defined as a return for something substantial and valuable given, which not being a necessary of life no one need contribute to unless at his own option. The Government in this case becomes the furnisher instead of some private speculator or contractor, who would for certain profits to himself be willing to supply the public demand for the article in question if the Government assigned to him the right so to do.

Tax on the other hand is a mere charge extorted by some ingenious method, without any portion of value given by Government in reference to the particular article on which the charge is made, but simply as a state necessity, to meet expenditure incurred under other heads.

	£	£
Taking the future normal expenditure of India at		26,089,737
The *Revenue* is actually . .	24,293,817	
Do. Prospective . .	14,760,000	
Taxes	6,449,288	
Balance Income . . .		19,413,368
	£45,503,105	£45,503,105

30. It were of little avail now to show what might have been done if the power of still doing it had passed away. This financial policy however may still be adopted, and when adopted will produce a large reduction of expenditure with a large increase of revenue. It will enable the repeal of the onerous salt tax—of the excise—the import and export duties; in short, of every impost, direct and indirect. It will provide for a proper establishment of the police, the judicial and education departments. It will liquidate not only the existing public debt, but likewise the large investments required for the construction of railways and of irrigation canals, leaving a *surplus* annual revenue exceeding £19,000,000 to be ultimately applied to the reduction of the land rent, &c.

31. Assuming that after completion of the indispensable improvements all the state incumbrances may be liquidated in a period of about twelve years, whether those heretofore incurred to meet deficiencies of revenue, or those still required for a similar object for the next two or three years, as well as for the contemplated reproductive investments; assuming, also, every direct and indirect tax to have been removed; the application of the large surplus revenue afterwards to the reduction of the land rent would then indeed become a vast benefit, in diminishing the charge upon land produce or the first necessaries of life.

32. This benefit would be felt even beyond the British territories. The rate of rent paid upon our vast extent of surface must in fact regulate the rates paid in the territories of Native states, where overcharges would produce emigration to the British territories.

33. It is clear that no such benefits could be hoped for were the fee of the land in the possession of numerous individual inheritors. Not even if it were possible to imagine Indian sirdars on a par with our own unparalleled, enlightened, and chivalrous nobility and landed gentry.

Land must in such a case be dealt with as any other private property, and therefore be rented at its full market value. The revenue necessary for a state must be regulated to meet a certain indispensable expenditure, whilst the revenue looked for by individuals, *even when most conscientious*, has no such limitation.

34. The security for the fulfilment of this financial principle rests upon four assumptions, that few will venture to controvert, viz. :—

First. That a large proportion may be added to the productive surface of India by the extension of Railways and Irrigation Canals.

Second. That the revenue from Railways, if *executed* judiciously, on account of Government, should give a net return of 8 per cent. on their cost to the public revenue. British Railways give about 4 per cent. on a mileage expenditure, five fold more than is required in India *with the experience now available*, which would thus, on the more limited scale of expenditure, be 20 per cent. The American Railway revenues have reached 8 per cent. on their cost in an agricultural county having a population of only nine souls to the square mile, whilst India, with richer resources, has 124 souls per square mile.

Third. That the returns upon judicious irrigation investments should average 40 per cent. It is to be recollected that works of this class cost less comparatively than any others, whilst their reproductive effect must be the greatest; and those who have considered the subject will not be surprised at the enormous profits realised in practice by the Government of India in the cases which they have dealt with. But, with such experience, all must be surprised that it should not have been undertaken on a scale commensurate with its importance, and solely upon Government account. Such a scale would secure for the fertilization of the land, within a certain ratio of expenditure, all the water that is now wastefully permitted to flow into the ocean in the dry seasons of the year.

Fourth. A most advantageous principle would be,—that the British Government should so far enlarge their policy in dealing with their Indian Empire as to join in the security on which the required loans may be obtained to bring about the rapid industrial and financial development here contemplated in that country. The question is whether for a mere point of etiquette they will put themselves (for I treat British interests as identical with the interests of India) to an unnecessary cost of about £5,000,000 a-year, for some years to come, by forcing upon India the necessity of borrowing, at 5 or 6 per cent., what might, under a British guarantee, be obtained at $3\frac{1}{2}$ per cent.

35. India is the only Foreign British Possession which yields to this country large and direct profit, whilst every other colony causes considerable direct outlay. It would not only be *equitable but possible* to have a return for the accommodation here suggested by placing a fair proportion of the British fleet on the Indian establishment, as the Army in the East already is; assuming that the Indian finances were on the wholesome footing of which they are susceptible.

36. No reasonable statesman could object to such a portion of the general expenditure of the United Kingdom being borne by the respective colonies as their circumstances, taking them as integral portions of the Empire at large, might warrant, and recollecting that they all enjoy the

security of the British flag: a security valid in the exact ratio that it is sustained by an expenditure that shall provide an efficient naval and military armament as compared with the forces of other empires.

37. Such a contribution upon our colonies, if *equitably calculated*, could not be objected to as unfair. *There is, however, a strong practical objection:* that, with the exception of India, it could not be paid; and the exception in the case of India is entirely due to the wise policy of having in that country preserved the public property of the State, or fee of the land, without assigning or alienating it to private individuals! Had the rest of the Indian policy been in keeping with this exceptional example, its rulers would have proved themselves the most beneficent that ever governed a country.

38. Bearing upon this point, there is a subject which at present excites much popular attention, that of introducing the settlement of Europeans in India by means of grants of territory in that country. It is earnestly to be hoped that any measure adopted with this view may be strictly limited by justice as regards the natives, and also within the sound financial policy which has heretofore governed this branch of the administration of India,

1st. By reserving a fair rent to the Government.

2nd. By giving no privilege to strangers which shall not be as equally and as generally applicable to the natives of the soil.

39. If this principle be strictly maintained, and followed up to its full development by an energetic fulfilment of those responsible duties inseparable from the ownership of landed property, a very few years must place the Indian population in a most flourishing condition, and must exhibit that which has never before been recorded in the annals of any Government administration,—an overflowing exchequer without a single tax, direct or indirect.

Police and Criminal Jurisprudence.

40. Having thus far dealt with the general principle of finance in India, we shall now proceed to consider some of the leading subjects of the Government executive administration in that country.

The two last years have given abundant proof that the military department is the first in importance, but it is a no less undeniable fact that the number, the organisation, the discipline, and the efficiency of our Indian armies must mainly depend upon such a police organisation being established in aid of the civil authorities *as shall enable the latter to enforce a due administration of the laws*, and as shall relieve the troops entirely from civil duties.

41. However military the form of Government may be, there must be a magistracy and police force sufficient for the ordinary control of the population, irrespective of the regular military force. The organisation and functions of these two classes of force should be on totally different principles. The police for individual action, or to be employed in small bodies, as the moral representatives of order and law. The military to act in large physical masses, *only to be used as an agent of internal government*, when the barriers of law and order have been seriously invaded by

some anarchical tendency in the people, and when moral restraint, backed by the minor police force, has been overcome or seriously threatened.

42. The ablest commanders and authorities on military matters have at all times resisted the employment of troops in those ordinary duties that ought to be executed by a well organised police.

This subject has been a source of much *bitter discussion and irritation*, from time immemorial, between the civil and military authorities in our Indian empire; of *innumerable ruptures and misunderstandings* where the public interests require *the most cordial sympathy and co-operation to exist.*

43. The records of the Irish Government administration would exhibit similar effects from similar causes. So long as deranging influences and defective police in that country forced upon our army the duties of a constabulary, so long were the people rebellious, *the regiments employed there ill-disciplined,* and the *military commanders dissatisfied and remonstrant.* As soon as the police organisation introduced under Colonel M'Greggor had time to produce its effects *the evils vanished,* and the principle is as applicable to India as it was to Ireland, but more important would be its application in the ratio of the respective populations whose interest would be thus affected.

44. It is necessary here to give some idea of the police department throughout India, and *in doing so we shall scrupulously avoid* the description of men opposed to or desirous of criticising the administration of public affairs, and quote only the best informed and highest authorities in the Government itself from time to time.

45. The earliest record to which it is requisite to refer on this subject is the Report of the Committee formed by Lord Auckland when Governor-General, in 1838, to investigate the state of the Bengal Police. The present Lieutenant-Governor of Bengal was a member of that Committee.

46. At Par. 4, speaking of the improvements urgently required in the police, the Committee state, "*That urgency is admitted on all hands;* but it arises more *from the unpopularity of our system,* AND THE GRIEVOUS OPPRESSIONS CONNECTED WITH ITS OPERATION, than from any increased disposition to crime on the part of the community at large," &c.

47. At Par. 5, the Committee say, "The defects in question pervade every grade of the (police) establishment. . . . The magistrates are overwhelmed. The daroghas and their subordinate officers are corrupt; the village watchmen are poor, degraded, and often worse than useless; and the *community at large, oppressed and inconvenienced* in various ways, are not only disinclined to afford aid to the police, but in most cases *had rather submit* QUIETLY TO BE ROBBED than apply to the police officers for assistance to *apprehend the thieves*, or *to recover the stolen property.*"

48. At Par. 8,—"To the union of the office of *magistrate and collector* injurious effects are generally attributed. The union which formerly subsisted between the offices of *judge and magistrate* was not as prejudicial, because POLICE *was the primary* object of the judge and magistrate, *but it has been* SECONDARY WITH THE MAGISTRATE AND COLLECTOR. Civil business, it has been observed, can wait; but the Government cannot wait for its revenue. In *neither* case, however, is such a union desirable. If there be more business upon the whole than one man can perform, *a part must be neglected; and it has happened in both instances,* and must be invariably the

case, *that the neglected portion is that in which the Government for the time happens to take the least interest.*"

49. At Par. 9, they say, "Mr. W. A. Pringle, in his letter of the 7th Feb. 1837, has remarked upon this point as follows:—'While the revenue department is, as it ought to be, considered of such primary importance, it is in vain to expect that police will be anything but a secondary consideration with a collector and magistrate.'"

50. At Par. 10,—"Moreover, a deputy is not always afforded, and in such cases the whole of the double duty falls upon one and the same individual, who is likewise in some districts *collector of customs, superintendent of salt chowkees, deputy opium agent,* and has charge of the abkara and stamp departments."

51. At Par. 12, speaking of the offices of magistrate and collector, they say, "The majority of the Committee, in concurrence with almost the whole of the gentlemen both in and out of the Service who have been asked their opinions on the subject, think decidedly that the efficiency of both departments would be much better secured, generally speaking, by intrusting the superintendence of each to a distinct functionary."

52. At Par. 18,—"The next defect we have to refer to as exercising a very baneful influence on the efficiency of the *police,* and the comforts of the inhabitants, *is the great extent of country over which the jurisdiction of each magistrate extends. This not only places it out of his power, except very rarely, to hold any personal communication with the people under his charge at their own homes, or to become acquainted with the remoter localities of his district, but it also prevents him from exercising* ANY EFFECTUAL CONTROL OVER THE CONDUCT OF HIS THANADARS, *his only instruments for preserving peace and good order, who are,* in consequence, NOTORIOUSLY CORRUPT, and often THE OPPRESSORS OF ALL AROUND THEM. It is also in a great measure the source of that dislike so generally entertained to having anything to do with police matters, *inasmuch as the intolerable inconvenience to which prosecutors, witnesses, and defendants at a distance are exposed, from the necessity in every case of attending the magistrate's cutcherry, is owing to that cause.*" On the latter point Mr. Ross observes, in his Minute of the 22nd May, 1832, "Not only are there no inducements held out to the people to give their aid in support of the police, but, on the contrary, *our* REGULATIONS *have the effect of making them endeavour to conceal offenders.* This is really the effect of the existing provisions for administering criminal justice, *which effect they produce by subjecting the people to the most serious hardships whenever offenders happen to be apprehended.* The hardships alluded to are much more severely felt than would seem to be supposed; *and their effect is not only to prevent the establishment of a good police,* BUT TO CREATE DISLIKE TO GOVERNMENT. *Under the existing regulations,* IN ALL CRIMINAL PROSECUTIONS the prosecutor and witnesses must *give their evidence in the magistrate's cutcherry.* IN THE MOST TRIVIAL CASES *they are compelled to undergo the fatigue of a journey to the station of the magistrate, in many cases exceeding a distance of* 100 *miles, to submit to* THE HARASSMENT OF A DAILY ATTENDANCE IN THE MAGISTRATE'S COURT FOR WEEKS TOGETHER,—*it being in almost every case found necessary, in order to procure the attendance of those who are required to appear as prosecutors and witnesses, to seize and send them to the magistrate's station under the charge of burkundazes, and, while there, to* KEEP

THEM UNDER RESTRAINT, AND SOMETIMES IN CONFINEMENT, *on the pretext of accommodating them with lodgings.*"

VILLAGE POLICE.

53. At Par. 45, the Committee observes: "We now come to the most important subject connected with the police of Bengal, namely, the state of the chowkedaree establishment. *In some districts their numerical strength appears to be very great, yet they are utterly inefficient, and have been described in the most unfavourble terms.*" Mr. W. T. Hawthorn, Judge of Zillah Cuttuck, in his letter already referred to, observes, "*That from the total absence of any supervision over the village police* for a series of years, it may be said that at present such a body does not exist. The race of people denominated chowkeedars *retain the name apparently to blind the people as to their real character.* They are employed during the day to assist the zemindar in collecting his rents, *and at night they act as the agents* of notorious characters *to point out* where property is to be found. They seldom realize by honest means above one or two rupees per mensem at the utmost, and are therefore always ready to connive at offences on the promise of getting a share of the stolen property. It is not an uncommon trick amongst the chowkeedars to apply for leave of absence before a burglary or dacoity takes place to quiet suspicion against them, after having informed where property is to be found, and the time and manner in which the theft can be accomplished with the least chance of detection to the parties concerned."*

54. At Par. 46.—Mr. Hawkins, in his letter dated 11th January, 1837, says, "*Many a magistrate must have observed that a man has turned chowkeedar merely because it gives him an excuse for leaving his home at night, in order that he may go upon his thieving expeditions.*"

55. In a Minute by Sir George Clerk, when Governor of Bombay, on the subject of police in that presidency, and dated 28th April, 1848, we find the following:—

At Par. 1.—"It seems to me that the police throughout this presidency is on a footing in several respects most unsatisfactory."

At Par. 4.—"Here we have signal proofs of the influence of our present system of police, &c."

At Par. 5.—"Thus the insecurity of the high roads throughout the greater part of this presidency has become lamentable."

At Par. 9 to 15 is given the numerical force of police in the Bombay Presidency, amounting to 71,989 individuals, and costing £244,269, exclusive of some irregular corps then employed on police duties.

This Minute makes some very important suggestions for the correction of abuses.

56. The present Lieut.-Governor of Bengal, in his Minute of 30th April, 1856, states at Par. 3, in reference to the Tanna Police, numbering about 9,000, placed at 484 stations, in a territory of 150,000 square

* In Lower Bengal alone this branch of the *police* numbers 164,877. See Despatch from Government, 14th May, 1857, page 54. This gives over one of these police bandits to the square mile, as they are pretty equally distributed.

miles, having a population of 35,000,000. "For what after all has been done to improve the police during the last thirty years? We have ceased, it is true, to expect integrity from daroghas, with inadequate salaries and large powers, surrounded by temptation and placed beyond the reach of practical control; and we have somewhat curtailed the excessive and unmanageable extent of our magistrates' jurisdiction by the gradual establishment of thirty-three subdivision magistrates."

57. At Par. 10, referring to the village police, of whom there are 164,877 in his districts of 150,000 square miles, he states, "Village watchmen are now declared to have no legal right to remuneration for service, and (the help of the magistrate being withdrawn) they have no power to enforce their rights, even if they had any right to enforce. *Hence they are all thieves or robbers, or leagued with thieves and robbers, inasmuch that when any one is robbed in a village it is most probable that the first person suspected will be the village watchman!*"

58. And at Par. 13, in referring to the general statistics of three given years, he shows that 1130 of the village police were convicted of crimes, when, according to the ratio of their numbers, as compared with the crimes committed by the entire population of the same districts, the number for the police would have been but 321, or little over one-fourth of what they were; whilst of the 1130 crimes committed by the police, 19 were murder and Thuggee; 39 burglaries; 357 robbery and theft,—that is to say, "nearly one-fourth more in proportion to their number for these heinous crimes than were convicted in all the lower provinces of Bengal for all offences of every kind."

59. On the 24th September, 1856, the Court of Directors addressed a Despatch to their Governor General in India from which the following are extracts :—

Par. 1. "Our attention has been directed, on various occasions of late, to the character and proceedings of the police in different parts of India, and the reports, which from time to time have been laid before us, have combined, with many incidental notices of failure or abuse, *to deepen the conviction, that an immediate and thorough reform of police* IN ALL THE OLD PROVINCES OF BRITISH INDIA IS LOUDLY CALLED FOR. Par. 7. "*That the police in India has lamentably failed in accomplishing the ends for which it was established is a notorious fact;* THAT IT IS ALL BUT USELESS FOR THE PREVENTION, AND SADLY DEFICIENT FOR THE DETECTION, OF CRIME IS GENERALLY ADMITTED. UNABLE TO CHECK CRIME, IT IS, WITH RARE EXCEPTIONS, UNSCRUPULOUS AS TO ITS MODE OF WIELDING THE AUTHORITY WITH WHICH IT IS ARMED FOR THE FUNCTIONS WHICH IT FAILS TO FULFIL, *and has a general character for corruption and* OPPRESSION. *There is, moreover, a want of general organisation; the force attached to each division is too much localised and isolated, and the notion of combination between any separate parts of it,* with the view of accomplishing the great objects of a body of police, is seldom entertained."

60. The most important documents connected with this subject, because they deal with remedies for the defects they expose, are those accompanying a Minute by the present Governor General, dated 14 May, 1857, relating to the system of police in the Bengal Presidency; and amongst these the very admirable Minutes by the Honourable J. P. Grant,

Member of Council of the Supreme Government in India, are of inestimable value.

The following are extracts from his Minutes of 23rd November, 1854:—

61. At Par. 11, Mr. Grant says, "I do not think that those general and obvious objections to the union of *fiscal, police,* and *judicial powers, in the same* hands, which are admitted to have weight, and which rule the practice in all the well-governed countries of the West, are inapplicable in any part of India. At this moment, in the Madras provinces, an inquiry is on foot into the truth of a charge that has been made formally in Parliament, to the effect that, in those provinces where magisterial and fiscal power are in the same hand, the Government revenue is systematically raised by the use of torture inflicted by the native officers vested with these double powers."

62. At Par. 20,—"According to my ideas, it ought to be our *fixed intention,* as soon as possible, to dissever wholly the *functions* of *criminal judge from* those of *thief-catcher* and *public prosecutor,* now combined in the office of magistrate. That seems to me to be *indispensable as a step towards* ANY *great* improvement in our criminal jurisprudence; and ANY change of system to be made meanwhile, *should be* contrived, I think, with *regard to this fundamental reform.*"

63. At Par. 27,—"In one way only has any progress been made towards supplying the one grand want of the Bengal system, namely, in the establishment here and there, in excessively large districts, of a small number of *subdivisions,* presided over by an assistant to the magistrate or a deputy magistrate. *I would work out this one sound improvement to the utmost.*"

64. At Par. 28,—"Every district is already divided into several moonsiffships. I would give every moonsiff criminal judicial powers to a certain extent."

65. Par. 29,—"Every district is already divided also into *thannas, but these thannas are often very large. I think* no thanna station should be more than ten or twelve miles from its neighbour on any side."

66. At Par. 30,—"*Every district should be wholly cut up into subdivisions. Over every subdivision there should be either an assistant or an officer such as is now called a deputy magistrate,* to superintend the thannadars, and to control the police of the subdivision,* BUT WITHOUT ANY JUDICIAL POWER WHATEVER. These appointments should be reserved for the future as rewards for the best conducted of the thannadars. If we make this service as hopeful as the native judicial service, why should we not have as good native deputy magistrates as we now have principal sudder ameens, and as good thannadars as we now have moonsiffs? If we do not make service hopeful, what right have we to expect it to be good?"

67. At Par. 31,—"Sudder ameens are now located at the sudder stations, exactly where respectable officers of their sort are least wanted. I would increase their number and place one in each subdivision, with jurisdiction over the whole subdivision, and with criminal judicial powers to a certain extent,—say up to one year."

68. At Par. 32,—"At the sudder station, at his head quarters, I would

* This literally means a *police sub-inspector,* who ought not to be termed a *magistrate.*

place the officer now called magistrate,* denuded of all criminal judicial powers whatsoever, and restricted to the duties of looking after the subdivision officers, and the thannadars and subordinate policemen, of discovering crime and of prosecuting it in heavy cases to conviction. At the sudder station also would be tried, by principal sudder ameers, assistants, joint magistrates, and deputy collectors, and judges (by collectors also having powers for the purpose, if any collectors have time enough to spare), all the cases of too grave a nature to be tried by moonsiffs and sudder ameens in the thannas and subdivisions."

69. At Par. 34,—"If any one acquainted with the Mofussil will endeavour to realize to himself the state of things such as it would be under the above system, and then to compare that with the existing state of things in which *nobody can be lawfully tried for stealing an egg or for giving an impudent boy a cuff on the head without coming in perhaps* 70 *or* 100 *miles, with all the witnesses, to the sudder station,* I think he would admit that my plan would be an improvement. My system of criminal procedure would not be perfection, but it might be introduced in three months' time with the greatest ease and at a small expense. The existing system of criminal procedure, to speak of it in moderate language, is not like the system of a country administered by rational beings."

70. The following are extracts from the Honourable J. P. Grant's minute of 9th April 1857:—

At Par. 20,—" There is no longer any question as to the necessity of separating the functions of revenue and those of criminal justice, so far as native functionaries are concerned. This one decisive effect the torture report has had upon the European mind universally."

At Par. 21,—" I see not how incongruity of system and invidious and offensive class distinctions are avoidable if the union in European hands is persisted in."

71. Such was the objectionable character of the police force, as put forth in the preceding Government Reports, and brought prominently before the public and Parliament of England by the revelations of the Madras Torture Commission, as to determine the late Court of Directors that a reform must at once be established. The question was, what that reform should be? Mr. Grant felt that the evil went deeper than a mere police derangement; that it seriously impaired the administration of criminal justice by the union of incompatible functions in the same individuals,—the magistrate or criminal judge holding the office of chief of police, and in some districts the three offices of tax collector, police officer, and criminal judge or magistrate. His recommendations urge, most vehemently and unanswerably, the necessity of severing those functions wherever they are combined, and placing each department under a separate control, totally distinct from the others.

POLICE REFORM.

72. Sir Charles Napier was the first to prove in his practice, that a sound principle of police organisation could without difficulty be applied

* This means a county or chief inspector of police, not a magistrate.

to India. His earliest efforts in the administration of Scinde were successfully devoted to effect that vital improvement, and his example has been more or less adopted on the subsequent acquisitions of territory.

In a communication addressed by him in 1846, when Governor of Scinde, to the President of the Board of Control, we find the following: "To secure the peace of the country, and avoid disseminating the troops, which would render them familiar with the people, and possibly diminish the wholesome fear of our power, I established a police of 2400 men, well armed, drilled, and divided into three classes,—one for the towns, two for the country,—the first all infantry, the two last infantry and cavalry, called the Rural Police. They assist the collectors, *but form a distinct body* under their own officers.

Again, "Meanwhile, I have to say, the large force in Scinde has not been *for* Scinde, but for the Punjaub. I have for two years constantly said, that 5,000 men are sufficient and more than sufficient for the defence of, and for the maintenance of tranquillity in, Scinde."

73. Sir Charles Napier knew that an undisciplined, underpaid, or ill-controlled police are most insufferable oppressors, instead of what they ought to be under a proper organisation, the most efficient protectors of the people; and that upon their conduct, as representatives of the Government, *ramified into every hamlet*, they must be most active promoters either of loyalty or disaffection towards their Sovereign. Hence a perfectly sound principle of police he aimed at as the most critical and important of all Government departments. He would never consent to corrupt or deteriorate his troops by imposing upon them police duties, because he knew it to be the most costly as well as the most impolitic course he could adopt, whether as regarding the interests of the people, the government, the police, or the army. Thus, in proportion to the sound discipline and correct principle of action with which he could inspire his police, he was enabled to propose reductions in the numerical strength of his troops, as regarded the requirements of internal government.

74. It is an undoubted axiom, that if the laws affecting a country be proximately equitable in principle, and that the agency by which they are executed be vigorously controlled, so as to prevent and detect the abuse of executive power, the result will be a loyal and contented population, with light burdens; whilst the most perfect laws, executed by a corrupt or ill-controlled subordinate agency, must produce popular discontent, large military establishments, and heavy Government expenditure.

75. The first essential principle, therefore, *far before railways* or *any other object*, whether as regards the interests and loyalty of the people, or the future efficiency and limitation of the military force, should be at once to convert both the thannah and village police force of India, which may be estimated at about 600,000, and have been described by the high authorities above quoted as a scourge upon the inhabitants,—to convert these brigands *into one thoroughly controlled and organised police force*, reduced to less than one-fourth of that gross number. The present crisis has brought about the opportunity and means to this end.

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76. If the principle of organising our native auxiliary troops in irregular regiments be adopted, there would be a surplus number of well-trained

British officers at once available as inspectors and sub-inspectors of districts to control and discipline the police.

77. Referring back to Mr. Grant's valuable recommendations, there appears to be one most important omission made by him in the future administration he proposes for the police and criminal justice; the omission, too, of a requirement equally called for *by every other judicial and executive department of the State*—

Circuit Courts.

78. Looking to the enormous extent of territory and population, and to the very limited comparative amount of administrative European supervision which can by possibility be applied, we at once find a difficulty which can only be met by the establishment of circuit courts and sessions in every department, to be presided over by European functionaries. This system, and this only, can afford the amount of British supervision required as a safeguard to the Indian people, whilst extending the judicial and executive powers of native agency, without which it is palpably impossible to administer an efficient Government suited to the requirements of 130,000,000 of people.

Territorial Division.

79. To apply this circuit system requires that a general territorial division of districts and sub-districts should be made on a well-digested principle, calculated to provide for the due supervision and requirements of every judicial and executive department.

The most generally understood and influential district division in India at present, and *to which everything else is made subordinate, is that of collectorate.* The name itself is objectionable, as calculated to convey the notion *that the first object of British rule is to gather up taxes.* Our own British nomenclature is preferable as conveying more generally the idea of government. The collectorate may be compared with the English county in its general bearings, and we find that the inequalities or unfitness of the districts in India as compared with the respective administrations of departmental superintendence are even more striking than in England.

80. Such inequalities, although very objectionable at home, are comparatively innocuous; because much of our public business is effected through the various systems of gratuitous local or municipal representative administration, emanating from an active and enlightened people, and operating for well-understood objects.

In India, on the contrary, every important or useful measure must emanate from and be superintended by a distinct official Government agency, conducted by a very small and costly class of officers, whose acts and motives are frequently uncongenial to the feelings, if not unintelligible to the apprehension, of the millions under their rule.

Hence the power of minute and efficient superintendence on the part of the few governing officials becomes the only solid security for the due exercise of that enormous responsibility which the British nation has

taken upon itself in India ; and it requires, as an essential preliminary, that the division of departmental districts and sub-districts should be based upon the most comprehensive and convenient system of which the circumstances will admit, instead of the anomalous, unconnected and impracticable principle which is their present character.

81. An analysis of the old provinces of British India shows the disproportion between the smallest, the medium, and the largest collectorates to be as follows: viz.

		Minimum.		Mean.		Maximum.
In Bengal	a ratio of	1	to	5	to	60
„ N. W. Provinces	do.	1	„	7	„	11
„ Madras	do.	1	„	2	„	4
„ Bombay	do.	1	„	6	„	20
„ Punjaub	do.	1	„	3	„	6

82. This would appear to be a fitting juncture to establish the whole of that subject on a footing that shall be free from the anomalies which we find operating at home as well as in India, where the territorial divisions appear to have grown up by chance. In England we find some counties manifold the size of others, both in area and population, although the general administrative arrangements in certain respects may be on an equal footing in each,—as Lincoln 2,776 square miles, and Rutland 150 square miles, or 18 to 1. These incongruities have forced in some egregious cases a division of the larger counties into sub-counties, as Yorkshire, Cork, &c. They are still so preposterous as to render necessary, with each successive legal enactment of certain classes, new and special divisions of the country suited to the particular requirements of each enactment.

83. These inequalities, however, in England are of comparatively slight importance, because every facility exists by which the inconvenience consequent to the larger districts is, to a great extent, neutralised. In India it is just the reverse. If a superintendence there be excessive, or beyond the reach of very reasonable exertion, as is generally the case, the functions of the office must be neglected, and the effect is most injurious to the interests of the people and the character of our Government. This tells upon districts of police, of magistrates, of justice, of education, of revenue, of public works, and of all other subjects, as it has told upon the military districts during the last conflicts. All departments are overstrained from the magnitude of the districts, the oppression of the climate, and the disproportion of the duties to the agency and means available for their execution.

84. A diagram will best explain how the judicial, police and all other districts having in view circuit courts and sessions, with departmental supervision and subordinate control, can be best formed to produce a general harmonious and mutually sustaining action throughout [*see Diagram*, p. 70]; how, in fact, Mahomet is to be taken to the mountain instead of continuing the effort to bring the mountain to Mahomet.

85. The British Indian territory of 837,412 square miles at present contains about 166 collectorates or departmental districts, answering, in their general objects, to English counties. Their defects are, first, great inequality in their comparative size and the duties they impose; second, deficiency in their combination into superior government districts or

provinces; third, deficiency in their sub-division into inferior departmental and subordinate districts, as baronies, petty sessions, police districts, &c.

Counties.

86. In seeking to establish order out of the elements now existing, it is requisite to keep within the most moderate limits (that will admit of practical supervision) the number of superior districts requiring able and highly-paid heads of departments. These we shall term counties, and estimate their number at 104, each having a radius of about 45 miles, and each being furnished with a head of every principal department, judicial and executive, whose jurisdiction and control would be respectively limited within the county boundary, the most distant point being within a six hours' ride or drive from the centre, and the stations of the subordinate deputies about four hours distant.

Provinces.

87. Four such county districts would form one convenient sized province of 32,400 square miles, under the general charge of a Government commissioner, thus making 26 separate Government provinces for the entire British Indian territory, each commissioner being within about eight hours' ride of the centre of each of the four counties under his charge.

Baronies.

88. The first sub-division of the county or departmental district would be into nine baronies of 900 square miles each, or spaces 30 miles square, the centre of which would be within two hours' ride of the extreme boundary.

Petty Session Districts.

89. The sub-division of baronies [*see Diagram*] might be either into nine of 100 square miles, or five of 180 square miles, or four of 225 square miles each, as petty sessions districts, elementary police districts, &c. according to the density of population. These are respectively shown on the diagram. Nine would, of course, be the most convenient, as bringing the central point within 5 miles of the district boundary; five would bring the central point within an average of 6¾ miles from the boundary; four would bring the central point within 7½ miles of the boundary. As regards the numerical strength and cost of the constabulary force, the division of the boundary into nine, five, or four police districts would make each county contain 81, or 45, or 36 police stations, and, allowing 25 men per station, with the requisite reserves, the cost for the entire territory of British India would vary from 4½ millions per annum for 81 stations per county to 2,721,533*l.* per annum for 36 stations per county, the latter sum being about the aggregate cost from all sources of the present defective thannah and village police of India taken together.

This financial comparison would probably be conclusive as to the adoption of a division of the barony into four petty sessions and police districts, a division of which no one would have a right to complain, as,

To face p. 70

Diagram to Illustrate a Division of Territorial Districts in India
Suited for Civil, Criminal and Appeal Circuit Courts.
Police organization and Control, Revenue Collection, General Government
Supervision of all Departments. Military occupation of the Country
And for the acquirement of Statistical Information

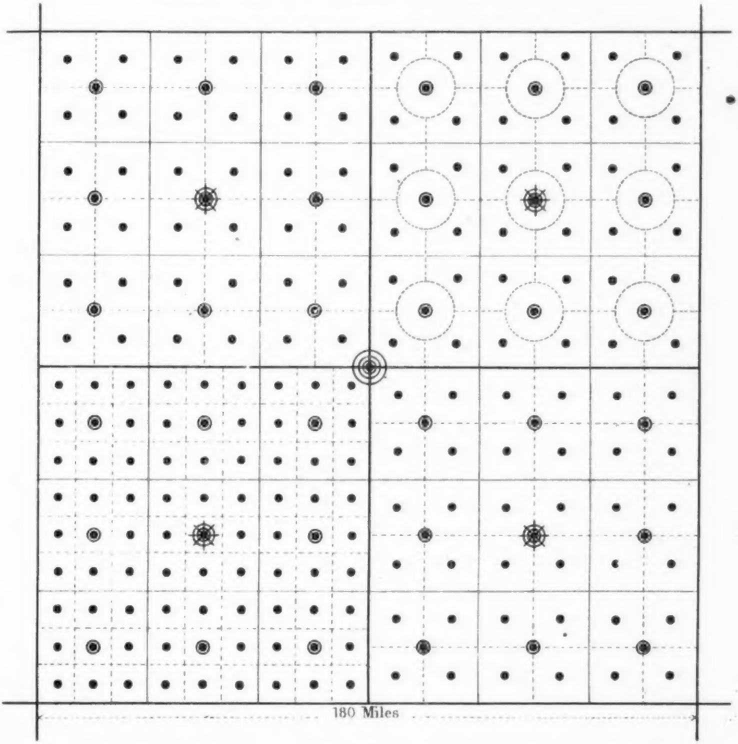

Diagram contains one Province of 32.400 Square Miles Average Population 5.000.000
British India 837.412 Square Miles would form 26 similar Provinces.

Centre of Province. Radius of Inscribed Circle 90 Miles. A Government Commr.s District and a Military Brigade district contains 4 Counties.

Centre of County, Radius 45 Miles contains 9 Baronies. A Circuit for Superior Civil Criminal and Appeal Courts, to sit at Centre of each Barony.

Centre of Barony Radius 15 Miles, contains 9. 5 or 4 Petty Sessions Districts. A Circuit for Inferior Civil and Criminal Courts, to sit at Centres of Petty Sessions Districts

Centre of Petty Sessions Districts, Radius 5. 6 ¾ or 7 ½ Miles, Petty Sessions District to contain 9 Elementary School Districts.

J.R.Jobbins.

regarding the administration of justice, it would bring the inferior circuit civil and criminal courts within 7½ miles of the most distant inhabitants of the land, and, as regarding the efficiency of the police and other executive departments, it would bring those in charge of such districts within 7½ miles of their boundary.

We shall, therefore, adopt for further detailed consideration the principle of dividing the barony into four sub-districts for police, petty sessions, and other administrative purposes.

Police Establishment and Organization.

90. The principal officer in charge of the entire police of the county might be called the county inspector. Of these there might be three classes, of which the salaries might be respectively 1,000, 800, and 600 rupees per month, giving one first-class inspector, one second-class, and two third-class inspectors to the four counties of each province; these might be in the first instance selected from field-officers or captains in the army.

Under the county inspector there should be nine sub-inspectors, one in charge of each barony. They should stand in three classes, of which the salaries might be respectively 500, 450, and 400 rupees per month, giving to each barony one sub-inspector of the first-class, one of the second, and seven of the third.

Under each barony sub-inspector there should be four chief constables, each in charge of the police party of twenty-five men in an elementary police district of 7½ miles radius, co-terminous with a petty session district. The chief constables should be natives, promoted by merit from the inferior grades, and being eligible, if deserving, of promotion to the higher ranks of sub-inspector and inspector. There might be three classes of chief constables: the salary of the first-class being 150 rupees per month, the second 100, and the third 80; and their proportion being one first-class, one second-class, and two third-class for the four stations of each barony.

Under the chief constables there might be three classes of constables, receiving 16, 14, and 12 rupees per month, and three classes of sub-constables, receiving 9, 8, and 7 rupees per month respectively. There would be also a proportion of mounted constables and sub-constables, receiving 20 rupees additional to the pay of their rank and class per month. This classification would have an important effect, by keeping constantly before the men the fact of frequent promotion for meritorious conduct, with a perfectly understood principle that the highest position in the force would be open to the exertions of every man in its ranks. The following Tables give the details in a general view:

TABLE of DETAILS showing the ESTABLISHMENT

		Elementary Police Station. District 225 miles square and 7½ miles radius. No. of Men.	Barony, 900 square miles, contains 4 Stations and Reserve.		
			Distributed at 4 Stations.	Reserve at Centre.	Total in Barony.
MOUNTED POLICE.					
County Inspectors	1	. .	. .	. .	. .
	2	. .	. .	. .	. .
	3	. .	. .	. .	. .
Total . .	. .	. .	. .	. .	. .
Barony Sub-Inspectors . . .	1	. .	. .	. .	. .
	2	. .	. .	. .	. .
	3	. .	. .	1	1
Total . .	. .	. .	. .	1	1
Chief Constables	1	. .	1	. .	1
	2	. .	1	. .	1
	3	1	2	. .	2
Total . .	. .	1	4	. .	4
Constables	1	. .	. .	. .	. .
	2	. .	. .	. .	. .
	3	. .	. .	. .	. .
Total . .	. .	. .	. .	. .	. .
Sub-Constables	1	. .	. .	. .	. .
	2	. .	. .	. .	. .
	3	. .	. .	. .	. .
Total . .	. .	. .	. .	. .	. .
Gross Total Mounted . . .	. .	1	4	1	5
FOOT POLICE.					
Constables	1	1	4	1	5
	2	1	4	1	5
	3	1	4	1	5
Total . .	. .	3	12	3	15
Sub-Constables	1	1	4	1	5
	2	1	4	1	5
	3	19	76	19	95
Total . .	. .	21	84	21	105
Gross Total Foot	. .	24	96	24	120
Gross Total Horse and Foot . .	. .	25	100	25	125

proposed for POLICE FORCE of BRITISH INDIA.

County, 8,100 square miles, contains 9 Baronies.			Province, 32,400 square miles, contains 4 counties.	British India, 837,412 square miles, contains 26 Provinces.	Monthly Pay per Man in Rupees.	Yearly Cost of proposed Police in British India.	
Distributed in 9 Baronies.	Reserve at Centre.	Total in County.	Men.	Men.		Rupees.	£
. .	1	1	1	26	1,000	312,000	31,200
. .	. .	. .	1	26	800	249,600	24,960
. .	. .	. .	2	52	600	374,400	37,440
. .	1	1	4	104	. .	936,000	93,600
1	. .	1	4	104	500	624,000	62,400
1	. .	1	4	104	450	561,600	56,160
7	1	8	32	832	400	3,993,600	399,360
9	1	10	40	1,040	. .	5,179,200	517,920
9	. .	9	36	936	150	1,684,800	168,480
9	. .	9	36	936	100	1,123,200	112,320
18	3	21	84	2,184	80	2,096,640	209,664
36	3	39	156	4,056	. .	4,904,640	490,464
. .	4	4	16	416	36	179,712	17,971
. .	4	4	16	416	34	169,728	16,972
. .	4	4	16	416	32	159,744	15,974
. .	12	12	48	1,248	. .	509,184	50,917
. .	10	10	40	1,040	29	361,920	36,192
. .	10	10	40	1,040	28	349,440	34,944
. .	64	64	256	6,656	27	2,156,544	215,654
. .	84	84	336	8,736	. .	2,867,904	286,790
45	101	146	584	15,184	. .	14,396,928	1,439,691
45	8	53	212	5,512	16	1,178,304	117,830
45	8	53	212	5,512	14	926,016	92,601
45	8	53	212	5,512	12	793,728	79,372
135	24	159	636	16,536	. .	2,898,048	289,803
45	8	53	212	5,512	9	595,296	59,529
45	8	53	212	5,512	8	529,152	52,915
855	152	1,007	4,028	104,728	7	8,795,952	879,595
945	168	1,113	4,452	115,752	. .	9,920,400	992,039
1,080	192	1,272	5,088	132,288	. .	12,818,448	1,281,842
1,125	293	1,418	5,672	147,472	. .	. .	2,721,533

STRENGTH, ORGANIZATION, COST, and DISTRIBUTION of POLICE FORCE proposed for BRITISH INDIA.

	Mounted Police.						Foot Police.			Gross Total.
	County Inspector.	Sub-Inspector.	Chief Constables.	Constables.	Sub-Constables.	Total.	Constables.	Sub-Constables.	Total.	
One Police Station for district of 7½ miles radius	..	..	1	..	..	1	3	21	24	25
BARONY.—Police Force in one Barony containing 4 Stations, and a reserve at centre. Radius of Barony 15 miles . . .	..	1	4	..	..	5	15	105	120	125
Reserve at centres of Barony . . .	..	1	..	..	..	1	3	21	24	25
COUNTY.—Police Force in one County 45 miles radius, containing 9 Baronies, and a reserve at the centre	1	10	39	12	84	146	159	1,113	1,272	1,418
Reserve at centre of County	1	1	3	12	84	101	24	168	192	293
PROVINCE.—Police Force in one Province 90 miles radius, containing 4 Counties . .	4	40	156	48	336	584	636	1,452	5,088	5,672
BRITISH INDIA.—Police Force in British India, area containing 26 Provinces . . .	104	1,040	4,056	1,248	8,736	15,184	16,536	115,752	132,288	147,472
WAR CONTINGENT.—Proportion of Police Force which might be temporarily detached in aid of military for objects of war, viz. Cavalry .	..	78	104	1,248	8,736	10,166	..	..	..	} 30,316
" " " Infantry	..	78	104	..	..	..	2,496	17,472	20,150	
	Rupees.	Rupees.	Rupees.	Rupees.	Rupees.		Rupees.	Rupees.		
Monthly rates of pay in rupees { 1st class .	1,000	500	150	36	29	..	16	9		
Monthly rates of pay in rupees { 2nd " .	800	450	100	34	28	..	14	8		
Monthly rates of pay in rupees { 3rd " .	600	400	80	32	27	..	12	7		
	£	£	£	£	£	£	£	£	£	£
COST.—Total yearly cost of proposed Police Force for British India	93,600	517,920	490,464	50,917	286,790	1,439,691	289,803	992,039	1,281,842	2,721,533

91. Such an organization would enable the sub-inspector of any barony to concentrate to the most distant point of his district, within six hours, 100 men.

It would enable the county inspector to concentrate rapidly 900 men to any one point of his district.

It would enable the Government commissioner of the province to concentrate rapidly 3,000 men on any point of his district.

It would enable the Government on any urgent emergency of war at once to reinforce the regular military reserve by a well-organized force of 10,000 police cavalry and 20,000 police infantry, and by recruiting to repeat such reinforcements to any extent required.

92. The gross cost of this police force, numbering 147,472 men, upon a liberal scale of pay, placing them beyond the *necessity of committing depredations for their livelihood*, would be 2,721,533*l*. per annum, or about the aggregate of what is now paid in different ways to the 600,000 depredators comprising the present village and thannah police. But from this estimated amount there would be the saving of the pay of the military officers—whose regiments having deserted them in the mutinies, leave them available for this most important organization. Thus we may calculate that the improved police and their officers, taken together, would produce a saving of about half a million annually, as compared with the former expenditure under these heads.

Civil and Criminal Jurisprudence.

93. Having corrected the most dangerous and oppressive system that exists in India, by disbanding the 600,000 village and thannah police, and organising a well-controlled and disciplined protective constabulary force of 147,472 men, the next subject in importance would be to improve the administration of justice, both civil and criminal—

First. By taking all judicial power out of the hands of revenue collectors and police officers.

Second. By establishing a moonsiff's barony circuit court in each barony, with both civil and criminal jurisdiction to a limited extent, for the trial of minor cases; such court to hold a session monthly at the centre of each of the four petty sessions districts in the respective baronies, and thus to decide all minor cases, both civil and criminal, within a maximum distance of 7½ miles of the suitors, &c. instead of forcing them, as at present, to travel long distances to sudder stations.

Third. By establishing a superior county circuit court for the trial of graver cases, both civil and criminal, and for hearing appeals from the minor or moonsiff's circuit courts. The superior county circuit court to hold quarterly sessions at the centre of each of the nine baronies; thus making the maximum distance for suitors, &c. to look for justice in the heaviest cases fifteen miles, instead of the present radius of the sudder district.

94. Taking the average annual number of persons apprehended on criminal charges in the provinces of Lower Bengal for ten years, ending 1852, at 91,261, as recorded at page 76 of Despatch from Government of India, dated 14th May, 1857, we may compare proximately the oppression

of the fixed sudder station principle with the relief that would be afforded by circuit courts and rotating functionaries.

The proportion of the above-quoted 91,261 criminals due to an average county of 8,100 square miles, as shown in the diagram, would be about 16,290, equally distributed throughout the county; and allowing the due proportion of witnesses and others engaged on the prosecution and defence, say ten individuals in each case, to have made two journeys between the places where the offences were committed and the places of trial, the comparison would stand thus as regards the miles travelled by the various parties: viz.

If tried on the old principle at the one centre of each large or county district, 15,228,000 miles.

If tried at the nine centres respectively of baronies, 7,531,000 miles.

If tried at thirty-six points of the nine inferior circuit courts, which is the principle we have adopted for economy in our calculations, the miles travelled in each county for the trial of criminal cases in one year would be only 3,758,000.

It is clear that the great mass of the cases would have been within the jurisdiction of the minor courts, and therefore the saving of oppressive embarrassment to the people of a single district, amounting to only 1-28th part of Lower Bengal, in a single year, and in but one branch of the administration of justice, would have approached 11,469,600 miles of journeys. We may fairly consider that this saving may be increased three-fold by taking into account the superior civil court business, and the attendance of the people upon the various other public departments, making a total saving to one county of 34,408,800 miles travelled, which, multiplied by 104, the number of counties of the same size proposed for British India, would reach the enormous amount of 3,578 millions of miles of harrassing journeys that British Indian subjects would be relieved from in the year if circuit courts and sessions were established at convenient points, as in England, at which the public functionaries should periodically meet the people in their own districts instead of dragging them to the one fixed centre of each large district.

95. It must be kept in mind that the diagram county contains 8,100 square miles, or what would be nearly equal to one-sixth of the entire surface of England, whilst the next class of district or barony is about three-fourths of the area of an average English county.

Until circuit courts, applied to a convenient territorial division, shall have been established, it is idle to expect that justice can be duly administered in India.

To effect upon the old principle of fixed functionaries the degree of relief here proposed as regards government departmental supervision, it would be requisite to multiply by nine the existing number and consequent cost of the most expensive class of functionaries, whereas, with the alteration proposed, a considerable reduction of the existing expenditure might probably be effected.

Hence the due administration of justice, and of an efficient executive government in its various departmental functions, must remain impossible problems until the authorities shall move round their districts holding their sessions periodically at fixed places and times. There is no other

means of meeting the physical impediments interposed by vast distances and areas as compared with the largest amount of competent Europeans that can practically be supplied.

Military Forces.

96. Assuming the four great essentials to security, justice, industry, and good government to have been accomplished—

First. By disbanding the 600,000 "unscrupulous" men denominated police in all the old provinces of British India, and by organising instead of them a well-controlled and disciplined constabulary of 147,472 men, closely superintended by their own officers, who shall have neither judicial, tax-gathering, nor other conflicting duties to divide their attention.

Second. By entirely separating the incompatible functions of joint collector, police officer, and criminal judge.

Third. By establishing a new division of districts and sub-districts with *circuit* courts, which shall bring the administration of justice into every man's immediate neighbourhood, instead of forcing all those engaged in the more important civil suits, and in every class of criminal case, whether as parties or witnesses, to travel to fixed sudder stations at the centres of large districts.

Fourth. By constructing a sufficient amount of railway intercourse to permit the full development of productive industry, and the rapid movement of troops towards any given point.

97. Assuming these indispensable preliminaries effected, and the incentives to popular discontent to have been thus removed, we can fairly consider the number, the composition, and the organization requisite for a military force suited to such altered circumstances.

98. The regimental organization, discipline, and drill of the British army are probably as perfect as it is possible to make them. But the minute distribution of the forces in times of peace renders it very difficult to maintain the aptness requisite in dealing with combined bodies of troops, their movement in masses, means of transport, commissariat supplies, and military stores.

99. The effective police force above suggested for India will render unnecessary in that country the minute fragmental distribution of the military, which may have been heretofore unavoidable; and the smallest corps which under the improved system need be detached, with a view to the most effectual military occupation of the country, we may consider as a brigade composed of one European and one Native regiment of infantry, one European and one Native squadron of cavalry, one nine-pounder field-battery of European artillery, and one company of European engineers: on the aggregate 2,500 men, one-half being Europeans. According to the territorial divisions already proposed, one brigade so composed would be stationed at the centre of each province or Government commissioner's district, having a radius of about ninety miles, and three such contiguous brigade districts might form a divisional command.

100. The entire territory of British India would thus be comprised in

twenty-six brigade districts, co-extensive with the Government provinces already described, and distributed as follows: viz.

In territories now under the immediate management of the Governor-General of India	.	8	brigade districts.
Territories under Lieut.-Governor of Bengal	.	7	do.
Do. do. North-west provinces	.	3	do.
Do. Governor of Madras	.	4	do.
Do. do. Bombay	.	4	do.
Total		26	brigade districts,

occupied by 2,500 men each, would absorb, for the general occupation of the country, 65,000 men. The radius of the district of each brigade of 2,500 men would thus be about 90 miles, or four forced marches, which would likewise be the measure in time required to concentrate any two contiguous brigades upon their mutual boundary, thus bringing together 5,000 troops, on an emergency, in four days: four brigades, comprising 10,000, could, in an equally short period, be concentrated from four contiguous provinces at or near their common angular point.

101. In addition to this distributed force, a disposable reserve of say fifteen brigades, comprising 37,000 men, would be requisite to meet every contingency that could arise, making the total military force about 100,000 men. The reserve force would naturally be posted in strong bodies of a division, each at strategic points, on our principal line of defence, guarding alike our most populous districts, and the north-western, the northern, and the north-eastern frontiers; and our general position would be still further improved if Scinde, the important flank of this great military line, were put in close relation with the supreme civil and military authorities that regulate the Punjaub, North-west provinces, and Bengal, instead of being attached to Bombay as at present.

102. This distribution would correspond with the precautions required for some time to come as regards the principal localities of the past disturbances. It would meet in every respect the requirements of an efficient military occupation of the country.

It would secure a constant practice and training, to every branch of the army, in all those elements most essential to military success in the field, as well in reference to the staff as to regimental fitness.

It would place the location of a large portion of our British troops more within the discretion of their commander as regards the questions of climate and health.

103. Each presidency has within or near to it sanitary stations, with an elevation varying from 4,000 to 7,000 feet above the sea, and offering the most desirable change as affecting the health and comfort of Europeans in the summer heats: in the Madras Presidency the Neilgherries, 7,000 feet; in Bombay Presidency a continuation of the same range to Poonah and northwards, 4,000 feet.

The central districts of India have their Vindhya and Aravulli ranges; Bengal, the North-west provinces and Punjaub skirt the Himalayas from Darjeeling to Simlah and the Indus, affording ample selections as to climate and strategic fitness along the whole line.

We have therefore a right to look forward, after a matured settlement

of the deplorable disturbances which lately existed, and which happily are now crushed, to a future state of things that will admit of a very large proportion of the European troops in India being enabled to preserve their health during the summer in cool stations, from whence in any emergencies the train (when established—and much hangs upon this) will rapidly convey them to any required points of action.

Composition of the Army.

104. The composition of the army has been hitherto about 1 European to 5½ natives. In future the proportion would probably be 1 to 1, or nearly so; artillery all Europeans; engineers, sappers, and pioneers all Europeans.

The whole of the privates of the engineer corps should be trained as overseers and foremen, in order that, instead of acting as individual labourers or mechanics, they may be able to direct the labours of large masses of men. Thus the establishment of 2,000 sappers would admit of the profitable and well-organised employment of half a million of labourers, whether in military or civil works of utility or emergency; and one of the greatest deficiencies in India is the proper application of industry, which this organisation would tend to improve.

The army of India might consist of—1st. British troops from home establishment; 2nd. British troops on permanent Indian establishment, in equal or nearly equal numbers; 3rdly. British colonial troops, not natives of India, commanded by British officers; 4thly. Native irregular troops, commanded by British officers,—the number of the latter class not materially to exceed the aggregate of the three former classes. Every British regiment and colonial regiment not Indian, or from a tropical climate, should have two companies of natives attached to it, to be for the time under the orders of its commanding officer,—such attached companies belonging to certain native regiments allocated for this special duty. All native troops, both cavalry and infantry, hereafter to be raised should be Irregulars, and their commanding officers should have restored to them their former powers.

105. A Table is here necessary to offer a general view of the strength and distribution of the forces, both military and police, under the contingencies both of peace and of war.

The protection and defence of a people necessarily embrace the consideration of these two classes of force as complements of each other, and under the various political circumstances to which States are liable.

TABLE shewing the STRENGTH and DISTRIBUTION in PEACE and in WAR of the MILITARY and POLICE ESTABLISHMENTS proposed for BRITISH INDIA.

		Brigades.	Artillery, 9-pounder Field Batteries.		En-gineers.	Cavalry.	Infantry.	Total of all Arms.		Total Europeans and Natives.
			Guns.	Men.				Guns.	Men.	
PEACE DISTRIBUTION.										
Concentrated.										
Military force guarding frontier	European Troops	15	90	3,600	750	2,560	12,000	90	18,910	37,660
	Native Troops		. .	. .	. .	6,000	12,750	. .	18,750	
Distributed.										
Military distributed for protection of 26 Provinces, one brigade at centre of each Province	Europeans .	26	156	6,240	1,300	3,840	20,800	156	32,180	64,680
	Natives .		. .	. .	. .	10,400	22,100	. .	32,500	
Total Military, European and Native . .		41	246	9,840	2,050	22,800	67,650	246	102,340	102,340
Police.—Native Force under 1,144 *European Officers, viz.—*										
Reserves of 104 Counties, 293 men in each, Natives .		. .	. .	. .	. .	10,504	19,968	. .	30,472	147,472
Reserves at centres of 936 Baronies, 25 men in each, ditto		. .	. .	. .	. .	. .	23,400	. .	23,400	
Force at 3,744 Police Stations, 25 men at each, ditto .		. .	. .	. .	. .	. .	93,600	. .	93,600	
Total Police, Natives		. .	. .	. .	. .	10,504	136,968	. .	147,472	147,472
Total of Military and Police forces for British India		. .	246	9,840	2,050	33,304	204,618	246	249,812	249,812

WAR DISTRIBUTION.

Concentrated.											
Military.—Ordinary Reserve force concentrated.	Europeans	. .	90	3,600	750	2,560	12,000	90	18,910	37,660
	Natives	. .	. .	. .	. .	6,000	12,750	. .	18,750	
1st Reinforcement from Provincial Military Establishment	Europeans	. .	120	4,800	1,300	1,920	10,400	120	18,420	34,670
	Natives	. .	. .	. .	. .	5,200	11,050	. .	16,250	
2nd Reinforcement from Police Forces	Natives	. .	. .	. .	. .	10,504	19,968	. .	30,472	30,472
Total available for war	Europeans	. .	210	8,400	2,050	4,480	22,400	210	37,330	102,802
	Natives	. .	. .	. .	. .	21,704	43,768	. .	65,472	
Total ditto Europeans and Natives		. .	210	8,400	2,050	26,184	66,168	210	102,802	102,802
Distributed in 26 Provinces.										
Military distributed for protection of 26 Provinces, one brigade to every two Provinces	Europeans	. .	36	1,440	. .	1,920	10,400	36	13,760	30,010
	Natives	. .	. .	. .	. .	5,200	11,050	. .	16,250	
Total Military distributed, European and Native		. .	36	1,440	. .	7,120	21,450	36	30,010	30,010
Police under European Officers.										
Reserves of 104 Counties	Natives	. .	. .	. .	. .	. .	18,720	. .	18,720	117,000
Reserves of 936 Baronies, 25 men at each centre	ditto	. .	. .	. .	. .	. .	23,400	. .	23,400	
Force at 3,744 Police Stations, 20 men at each	ditto	. .	. .	. .	. .	. .	74,880	. .	74,880	
Total distributed Military and Police, European and Native		. .	36	1,440	. .	7,120	138,450	36	147,010	249,812
Total concentrated for War, ditto, ditto		. .	210	8,400	2,050	26,184	66,168	210	102,802	
Gross Total Military and Police, Europeans and Natives		. .	246	9,840	2,050	33,304	204,618	246	249,812	249,812

106. From this Table it appears that the mutually sustaining forces of military and police would, by the establishments proposed, amount on the aggregate to 249,812 men, of whom 102,340 would be military, one-half being European, having 41 nine-pounder field-batteries of artillery, or 246 field-pieces, and 22,800 cavalry. The remaining 147,472 would be native police under British officers, of which 10,504 would be mounted and organised as irregular cavalry, and 19,968 as irregular infantry.

That their distribution in peace would be as follows:—

		Men.
Military.—Concentrated Reserve Force, 15 brigades . .		37,660
" Distributed in single brigades at centres of 26 provinces		64,680
Police.—104 County Reserves of 293 men each, one-third cavalry, two-thirds infantry, armed and organised as irregular troops to furnish gaol and treasure guards, &c. .	Men. 30,472	
" 936 Barony Reserves of 25 men each ditto .	23,400	
" 3744 Police Parties of 25 men each with side-arms	93,600	
		147,472
Military and Police distributed during peace for protection of 26 provinces		212,152
The distribution during war would be as follows:		
Forces which can be concentrated for war:—		
Military concentrated for war, ordinary reserve .	37,660	
Do. do. 1st reinforcement, 26 brigades taken from distributed military force . . .	34,670	
Police do. 2nd reinforcement from County Police Reserves, one-third cavalry, two-thirds infantry .	30,472	
Total concentrated for war . .		102,802
Remaining Forces distributed in Provinces:—		
Military distributed in 13 brigades remaining in 26 Provinces	30,010	
Police.—104 Fresh County Reserves, drawn from stations to replace those sent to reinforce war force	18,720	
" 936 Barony Reserves, at ordinary establishment of 25 men each . . .	23,400	
" 3744 Police Parties, reduced to 20 men each instead of 25	74,880	
Total Military and Police distributed for protection of 26 Provinces during war		147,010
Gross Total Military and Police .		249,812

107. The power of reinforcing the army from the ranks of the police may be carried to any required extent, provided the police be recruited, as they ought to be, for general service. Such reinforcements would naturally be furnished from the county reserves, which would be filled up again as regards the infantry by drafts of selected men from the barony reserves and station parties. The police cavalry would be recruited from practised horsemen, and the recruiting for the army through the police, spread over every district of India, would be a much safer principle than that heretofore adopted in Bengal.

108. The county police reserves we have estimated at about 100 cavalry and 200 infantry for each county, and, as there would be four counties to each Government commissioner's province, this would give a total county reserve force to the entire province of about 400 cavalry and 800 infantry. We have suggested that the centre of the province, or head quarters of the Government commissioner, should be the station for the military brigade; and, as the best protected point in the province, it should likewise be the position for the principal treasury and gaol, placing these establishments and the barracks for European troops, if not the entire brigade, within an earthwork redoubt or citadel.

109. Under this consideration the best position for—say two-thirds of the county reserves of the province, would probably be secured by concentrating them at the central provincial station or angular point where the four counties meet. This would provide an ample force of police for the gaol and treasury-guards, treasure-escorts, &c. and it would give the requisite security of a large force of military to those departments when particular emergencies might demand the presence of the police reserves in other parts of the province.

110. In fixing the permanent numerical force and composition of an army intended to protect the British Indian population and territory, an important subject for consideration would be the relative and aggregate strength and composition of the military resources of native states not under British rule. We find, and with reason, that the military forces of neighbouring states in Europe regulate more than any internal necessity the amount of force that each must maintain—relative weakness provokes aggression. Our capacity to resist aggression is the precise measure of our protection against provocation.

It is the only peace-preservation principle of any value in the present state of the world. In this view we must not overlook the statement given in a Parliamentary Return of 15th April 1852, which describes the forces of native states in India as amounting to 12,962 artillery, 68,303 cavalry, and 317,653 infantry, making an aggregate of about 400,000 men, or four times the number which is here proposed for the British Indian territory, although those states possess little over one-third of our population and about three-fourths of our area. Hence, according to our scale, the aggregate military of native states, instead of being 400,000 men, should only be 37,000 in reference to comparative populations, or 75,000 in reference to comparative areas. And giving a margin of 33 per cent. beyond the largest amount that either basis would bring out, as the aggregate military establishment of native states, we may admit 100,000 men as a reasonable limit to which they could scarcely object.

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Total concentrated for war		102,802

REMAINING FORCES distributed in Provinces:—

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Police.—104 Fresh County Reserves, drawn from stations to replace those sent to reinforce war force	18,720	
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112. The question of whether the military forces of native states are to stand at 400,000 men, or to be reduced to 100,000, is not so important as affecting the absolute results of future collisions between the British power in India and any combination of native states against that power, as in the effect that it would have in reducing the chances of any such collisions taking place. If they do occur, there can be little doubt of our success, whatever the numerical preponderance of their nominal troops may be.

Yet still, if they can see upon paper that a combination of their forces would be four times the amount of ours, such a view might easily mislead ambitious and designing chiefs to embroil the country in most fatal and destructive conflicts.

There can be no doubt that a calculation of the vast disproportion between the natives and Europeans, $5\frac{1}{2}$ to 1 composing the British Indian armies, was the real source of the late mutinies, with all their consequent horrors and waste.

If, therefore, our negociations with native states can produce a reduction of their 400,000 nominal troops to 100,000, such a result would tend to secure the permanent tranquillity of India, whilst it would confer immediate and permanent financial benefits on the rulers and people of those very states, by the reduction of nearly three-fourths of their present military expenditure, whatever that may be. The mode of dealing with this question will no doubt be a matter of extreme delicacy, but it is assuredly one of paramount importance, and as the paramount power in India it is one with which we are bound to deal; because, whatever we may do or leave undone there, we shall be charged, *and justly*, as the "paramount power," with whatever evils arise, whether in our own territories or in the native states.

113. Political clouds, portentous of a European war, have for months past overshadowed our commercial horizon with their inevitable and mischievous consequences upon the industry of the empire and the well-being of the world; and it is of the utmost importance that such a permanent and healthy basis of government should at once be established in our distant Eastern territories as shall enable our statesmen to turn their undivided energies and means to avert the threatening catastrophe and protect our central interests, which act and re-act between the heart of the empire and its remotest extremities with the most sensitive precision, each vibration to and fro conveying its particular quantity of good or evil with scrupulous accuracy throughout.

European Barracks.

114. One important point for consideration in the arrangements for an altered system in reference to the future military occupation of India is the subject of barracks for European troops. The first desideratum should be to render it impossible to overcrowd them. This can only be done by limiting the width and regulating the height, so that, when the utmost amount of beds has been introduced that the floor will admit of, there must still be the regulated number of cubic feet of interior space for each soldier, whatever that regulated space may be fixed at.

If we assume 6 feet by 4 feet for each bed and its side space, and allow

8 feet between the opposite beds for the table and forms, and take 1,500 cubic feet as the interior space per man, we shall have 20 feet as the width of the rooms in the clear, and 37 feet the height.

If 1,200 cubic feet be assumed as the required breathing space per man with good contrivances for ventilation, then the height would be 30 feet.

If 1,000 cubic feet be the regulated breathing space, then 25 feet becomes the height. And, in all cases in the plains in India, barracks for Europeans during the summer should be furnished either with the punka or thermantidote.

There should be a ceiling of some description, with a free circulation of air between it and the exterior covering, to prevent the direct heat from the roof striking down on the men's heads. The roof should be carried down and similarly ceiled to within 8 feet of the ground, to form a verandah.

European Officers' Quarters.

115. There can be no question that regular barracks should be provided by Government for the European officers as well as the men. There can be no security or strength in the old principle of laying out cantonments which cover miles of ground, and render their defence impossible by any moderate force, when the contingency occurs of considerable proportions of the troops of a cantonment being suddenly required elsewhere.

116. The whole of the costly buildings required for Europeans ought to be compact and defensible, with a small force, against any sudden assault; and officers' quarters ought to be included.

It is often a source of considerable loss to officers to be obliged to purchase or build their bungalows in a cantonment. Their allowance in lieu of lodgings is no doubt on a very liberal scale; still there is no certainty of an officer remaining at the same cantonment until that allowance shall have reinbursed him for the building or purchase of his bungalow, which he may be unable to sell at his departure in consequence of a reduction in the strength of the relieving force.

117. This contingency sometimes embarrasses officers very much indeed. It should be taken into consideration, together with the heavy subscription to which young officers are subjected in the first years of joining their corps. Their allowances, however liberal for their rank as compared with English pay, are unable to meet such charges.

118. Debts to banks are contracted at usurious interest, and a plausible excuse is thus offered for commencing what grows into a discreditable, a ruinous, and, from the above causes, almost an unavoidable, habit in India.

This entire subject of officers' debts and their origin is well deserving of the closest investigation, with a view to the application of effectual remedies. There can be nothing more injurious to the character of Englishmen in the eyes of native Indians than the frequent exposures which it entails at courts of request.

It has had the most earnest attention of our best commanders, but its source was beyond their reach under the existing regulations.

119. The very gratifying transfer of the Company's army to the service

of their Sovereign will necessarily render them subordinate to Her Majesty's Commander-in-Chief at the Horse Guards. His influence may enable him to remedy this and other existing evils, to remove all shadows from the brilliancy of the British character and achievements as exhibited to the numerous Eastern nations. There is no doubt that ascendancy won by military prowess can only be consolidated by high moral qualities in the victors, incessantly directed to ameliorate the condition of the people subjugated.

120. The government of India has been and must be practically a military government.

The Governor-General has been and must be practically Commander-in-Chief in India.

The nominal Commander-in-Chief has been and must be practically the lieutenant of the Governor-General.

Practically the functions of Commander-in-Chief in India have hitherto been limited to Bengal; they should extend to India generally.

There are some cases on record in which the offices of Governor-General and Commander-in-Chief were absolutely vested in the same individual.

121. I have now only to regret my short-comings in treating as it merits the discussion of these important subjects.

To the broad principle inculcated probably few will demur. That the removal of all that is oppressive or objectionable, and the establishment of all that can promote the easy administration of justice, and the free action of industry, trade, and commerce, will best secure to Her Majesty a loyal and prosperous population in India, and enable the future military force there to be brought within the lowest safe amount; whilst soundness in the composition, relative proportions, organization, and discipline of that mixed force will be the only security that the resistless British portion of it shall not again be provoked to so revolting and unequal a struggle, as they have just triumphantly undergone, in the defence of their Sovereign's honour, and of the vital interests of her British and Indian subjects.

Evening Meeting.

Monday, January 31st, 1859.

Colonel the Honble. JAMES LINDSAY, in the Chair.

The Chairman announced that twenty-two Members had joined the Institution since the 1st January.

LIFE MEMBER.

Sir John Kirkland, Army Agent.

ANNUAL SUBSCRIBERS.

Lenon, Jno. F., Lieut. R.N.
James, Edw. R., Lieut. R.E.
Fellowes, H. P., Capt. Royal Marine L.I.
Baynes, R. L., C.B., Rear-Admiral
Elderton, Edw. M., Esq., late H.A. Comp.
Wade, Seaton, Surgeon R.N.
Best, M. G., Major 34th Regt.
Jay, John L., Esq., Sec. to the Gov. Greenwich Hospital.
Hastings, Jas. C. J., Esq., Clerk Ord. Dept.
Conolly, Jas., Lt.-Col. Ass. A. G. Portsmouth.
Sims, Andrew, Comr. R.N.
Lloyd, Wm., M.D., Staff-Surg. H.M. Indian Army.
Coles, Cowper P., Captain R.N.
Eliot, Chas. G. C., Lieut. Gren. Gds.
Farquhar, Arthur, Captain R.N.
Haultain, F. W., Captain Royal Art.
Heyland, A. R., Ensign 56th Regt.
Inglefield, S. H. S., Captain Royal Art.
Turnor, Geo., Lieut. 2nd Queen's.
Stanley, Hon. F. A., Lieut. Gren. Gds.
Tremayne, Arthur, Major 13th Light Dgs.

NAMES of MEMBERS who have paid increased SUBSCRIPTIONS since 1st January, 1859.

Wade, C. H., Lieut.-Col. unatt.
Gascoyne, C., Major-Gen.
Bennett, T., Rear-Admiral
Cochrane, Sir Thomas, Admiral
Drummond, John, Major-Gen.
Mayow, G. W., Colonel unatt.
Phillott, C. R. G., Admiral
Abbott, James, Esq., late Dem^s. Mil.
Stopford, J. J., Captain R.N.
Hill, R. J., Esq., late Lieut. 1st Royals
Nason, J., Major Dep. Batt.
Newenham, C. B., Esq., late Ord. Dep.
Inglefield, S. H. S., Captain R.A.
Jay, John L., Esq., Sec. to Gov. Greenwich Hospital.
Baynes, R. L., Rear-Admiral.
Bent, W. H., Capt. R. E. Mid^x. Mil.
Malton, W. C., Lieut. Edm. Royal Rifles.

DONATIONS.

	£	s.
Monro, D. A., Maj. late 12th Lancers	1	0
Jefferson, R., Captain late Ceylon Rifles	1	0
Blair, W. F., Capt. R.N.	1	0
Vyvyan, R. H. S., Lieut. Cornwall Rangers	1	1
Packe, Edm., Captain late R. H. Gds.	1	0

PRESENTS.

LIBRARY.

Books.

(The Donors' Names in Italics.)

Révue Militaire Suisse. 2 Vols. 1856-57. 8vo. Lausanne.
Presented by Chief of the War Department, Berne.

Cambridge Essays for 1858; contributed by Members of the University. Concluding the Series. 8vo. London, 1858. *Presented by Colonel R. A. Shafto Adair.*

Nos. 1, 2, 3, Journal Militaire, 1858. Large 8vo.
Presented by Minister of War, St. Petersburg.

Archives for the Officers of the Prussian Royal Artillery and Engineer Corps. 8vo. Berlin, 1835-58. 22 Vols. *Presented by Minister of War, Berlin.*

Science and Art Almanack for 1859. 3 copies. *Presented by Henry Cole, Esq., C.B.*

Observations on Legislative Military Economy and Responsibility.—The Royal Artillery. 8vo. London, 1858. Second edition. 3 copies.
Presented by General Sir R. Gardiner, K.C.B.

British Association.—Earthquake Catalogue and Discussion, &c. 1 Vol. 8vo. London, 1858. By R. and J. W. Mallet, Esqrs.
Presented by Robert Mallet, Esq., C.E., F.R.S. (Hon. Mem.)

The Royal Artillery Institution, Occasional Papers of. No. 8. January, 1859.
Presented by the Institution.

Captain E. Finch Hatton, Northam. Mil. The Militia and the Recruiting Service, with Suggestions for their Re-organization. Pamph. London, 1859. 8vo.
Presented by the Author.

Atlas National de la France en Départements, revu et augmenté en 1806. Par P. G. Chaulaire, Directeur de Bureau Topographique du Cadastre.
Presented by John T. Delane, Esq.

MUSEUM.

Military.

A Nubian Club; 2 Egyptian Swords. *Presented by E. A. Corbet, Esq., 17th Lancers.*

Matchlock; Ball Pouch; Bullets; Bow; Sheaf of Arrows; Cartridge Box—obtained from the aborigines (a savage race of people) in the Island of Formosa.
Presented by Captain G. A. Brookes, R.N., H.M.S. Inflexible.

A Non-descript Implement, with five Barrels pointing to the front and one to the rear; A Cannon Shot, centre composed of Plates of Iron, over which the molten Iron has been poured; A Cannon Shot, of molten iron poured over a triangular mass in the centre; from the Chinese Arsenal, Canton. *Presented by W. Servantes, Esq., Depty. Ass. Comm.-Gen.*

Miscellaneous.

Round Shot recovered from "Cæsar's Camp," near Alexandria, in the immediate vicinity of the spot where, according to Lieut.-Col. Wilson, the 28th Regiment faced about and repulsed the enemy in the glorious action of 21st March, 1801.
Presented by Capt. Maycock, Ast. Qr.-Mr.-Genl.

Fringe worn by Nubian Women. *Presented by E. A. Corbet, Esq., 17th Lancers.*

CHAIRMAN'S ADDRESS.

Chairman. Gentlemen, before I call upon the honorable gentleman upon my left to read the paper which forms the subject of this evening's business, I will, with your permission, say a few words upon the occurrences which have taken place during the last year with reference to the Institution, and upon the progress which the Institution has generally made during that period. The first point which naturally strikes us as most worthy of observation, is the number of members who have joined the Institution during the year 1858. It is a source of great gratification to me (and I am sure it will be satisfactory to all who are members of the Institution) to announce that, with the exception of one year, the number of officers who have joined the Institution during the last year has exceeded the number who have joined in any year since 1837.

During the year 1858, two hundred and twenty-two new members have joined the Institution. This of itself shews considerable progress; but in one particular this progress is more important and satisfactory than appears at first sight; for in previous years it has caused us very great labor and exertion to keep up our numbers; but during the last year, without the slightest exertion, in consequence of the improvements and the progress which we have been making, we have found that officers of the Army and the Navy have come voluntarily and joined the Institution, instead of our having to

canvass them. I hold this to be a great element of success, and I think there is every prospect of our seeing the same good feeling continued.

During the year no less than seventeen members have increased their subscriptions from 10*s*. to 1*l*.; and, though undoubtedly the number who have recently joined the Institution proves the increasing estimation in which it is held, yet, as regards an improved financial position, so far as it is dependent upon numbers, we have, in reality, great difficulties to contend with. The smallness of the subscription has hitherto compelled us to depend upon numbers; but, from the constant deductions by death and withdrawals, and, I am sorry to say, sometimes by arrears, and also from officers retiring from the Service ceasing to pay their subscriptions, we have not hitherto, unfortunately, made any very considerable increase in the total number of subscribers. Generally speaking, the number of members we gain during the year seldom exceeds the number we lose. The finances of the Institution have, however, been during the past year in a very prosperous condition in consequence of members increasing their subscriptions. The whole subject of the finance of the Institution will, in the course of this year, be brought before a general meeting, when I hope we shall be able to put our financial system upon a secure and permanent foundation. The principal cause of the last year being so successful as regards the increase of members, is the publication of the Journal ; and I am happy to say that the more the Journal has become known, the more highly has it become appreciated, more particularly by those serving in Her Majesty's ships and regiments in foreign parts. We have repeatedly received letters from officers serving abroad expressing their high appreciation of the Journal, and their anxiety to become members of the Institution. We also thought it a good opportunity of entering into communication with foreign countries, and we accordingly wrote letters to the representatives of foreign countries residing in this country, offering to transmit our Journal to their respective war departments, in the hope that they would transmit their naval and military magazines or reviews to our Institution. I may point to this table as the happy result of that request for the interchange of publications. The Prussian government have sent us twenty-two volumes of a military journal; the Russian government have sent us three of a military review; the Sardinian government have also sent us their military journal; we have something of the same sort from the Canton of Berne; and also three volumes from Copenhagen. We received at the same time the most handsome letters cordially concurring in the proposition which we ventured to make. If we were a rich body (and I hope that in the course of time by the exertions we are making we shall become so) one of our objects would be, where we found a paper of value in one of those journals, to reprint it and publish it in our own. For instance, very few people can read Russian, and, if there were a Russian article which might be considered to be an important one, that paper might be, with advantage, reprinted and circulated for our own members. Such a course would enhance the value of our Institution, by enabling its members to ascertain the opinions and progress of other nations.

During the last year, I regret to have to record, we have lost by death many very distinguished officers. Some of these were generals and admirals who had been engaged in the Revolutionary War, and who had

arrived at an advanced age. Amongst the number who have died during the course of the last year, (and I am happy to say we have not had so many deaths as usual,) I will mention one who had been lately prominent in the service of his country, and also one who had ever been a most energetic member of this Institution. The first name to which I allude is that of Lord Lyons, who so lately commanded the Fleet in the Black Sea, and whose distinguished services, both as an officer of the navy and as engaged in the diplomatic corps, are so well known to his countrymen. The other name which I feel it my duty to mention to the members of this Institution, is that of the late Lieutenant Raper, of the Royal Navy. Mr. Raper was one of our earliest members. He joined the Institution at its foundation. Four or five years after he became a member he was put upon the Council, and, from that time to a year or two ago, he exerted himself for the benefit of this Institution, and was one of its most active members. He was distinguished by his scientific acquirements, and by the publication of a book on the Practice and Application of Nautical Astronomy, a work which is held in very high estimation in the Navy (and I think I am right in saying so, seeing that it has reached six editions), and for which he received the medal of the Geographical Society. All of us must deplore his loss, and those who served with him upon the Council well know the value of his practical ability, and the warm interest he took in the development of this Institution.

I will not detain you by reading the list, but during the past year a considerable number of members of this Institution have distinguished themselves in the service of the country. Many have been rewarded by promotion, others have been rewarded by being decorated with the Bath. Lord Clyde, an old member of this Institution, has been raised to the Peerage, and promoted to the rank of General Officer, for services well known to us all. There are several others who have distinguished themselves in the campaigns in India, and who reflect lustre upon this Institution by being members of it. I think it might perhaps be expedient to record, in some mode hereafter to be considered, the names of those officers who have been rewarded by the Queen for services rendered to the country, or who have been distinguished by promoting the science of their profession.

I am happy to be able to announce to the meeting, that, after His Royal Highness the Prince of Wales was appointed to a commission in the army, I requested His Royal Highness to honour the Institution by becoming a Vice-Patron. Her Majesty upon the part of the Prince was graciously pleased, through Sir Charles Phipps, to say that he would accept that office, and accordingly I wrote to Colonel Bruce, who is at present in attendance upon him, to inform him that he had been, by Her Majesty's consent, placed upon the list of Vice-Patrons. His Royal Highness desired Colonel Bruce to communicate to me his gratification in so becoming a Vice-Patron, and that he had been several times in the Institution, and had felt much satisfaction in inspecting the treasures contained in the Museum.

In conclusion, I think it my duty to express the obligations that this Institution is under to the Naval and Military departments of the country, and the warm interest they have exhibited in assisting the plans of the

Council. We have increased the Museum considerably during the past year, by articles and specimens of a practical character, calculated to promote useful information among the younger members. Upon the part of the Council I will add, that we shall endeavour to persevere in the course which we are now pursuing. We are gradually obtaining the good-will and countenance of the two Services. Our progress cannot be rapid, for we have to overcome many difficulties ; we have to show and to prove that there is an Institution in the country which is capable of collecting and conveying professional information. Gradually the officers of the Service are perceiving, that the more they become acquainted with all the details and with the science of their profession, the greater is the estimation in which they are held, and the higher pleasure will they take in all that belongs to it. This Institution is not yet what it will eventually become ; but there are elements of success contained in its design, and when once a professional feeling is enlisted in its favour, which will, ere long, I anticipate, be the case, it will not fail to become worthy of the Services and the Nation.

NOTES ON THE MAGNETISM OF SHIPS,

By Frederick John Evans, Master R.N., F.R.A.S., Superintendent of the Compass Department, Admiralty.

The object of the paper I propose to submit to the Members of the United Service Institution this evening, is, to describe, in as brief and popular a manner as the subject will admit of, the progress and the present state of our knowledge of the magnetic condition of iron and wood built ships, and the consequent effect on the mariner's compass; together with the means at our disposal for analysing or detecting its character, as also by offering such illustrations as may be worthy special remark, and, by recording the sources of my authority, to direct attention to the theoretical labours of the several eminent men of science who have contributed to this peculiar branch of knowledge so important to a maritime community.

It is probably within the recollection of many of the Members of the Institution, that a lecture was given some seven years past in this theatre by the late venerable Dr. Scoresby, treating in part on the same subject, and which then excited interest among many nautical men from the novelty of certain principles expounded, and to which I shall have occasion hereafter to revert.

The great increase of iron shipping since that time—short comparatively as it is—in our mercantile marine; and the colossal dimensions to which they have expanded; the further general introduction of huge steam engines, boilers, and shafts into our now gigantic frigates and ships of the line, all tending to highly develop the magnetic conditions of those fabrics, is of itself sufficient to invest the subject with interest, setting aside the fact that more than one disastrous shipwreck within the same period of time can be distinctly traced to unsuspected, or unallowed-for compass errors.

It may be interesting here to observe that the varying influence of the

iron of the ship on the mariner's compass had sorely baffled many of our early navigators, for we find Dampier, as recorded in his voyage of 1691-3, complaining of being "puzzled" at certain anomalies in the amount of the variation of the compass, on passing the Cape of Good Hope, and which was doubtless due to local attraction.

Again, we find Mr. Wales, the astronomer who accompanied Cook our illustrious navigator in his second voyage of discovery, stating distinctly that "variations observed with the ship's head in different positions, and even in different parts of her, will materially differ from one another; and much more will observations observed on board different ships."

In 1794, the first direct mention of the iron in the ship being the cause of disturbance, appears to have been made by Mr. Downie, the master of H.M.S. Glory, who in a report on a then newly-invented compass, observes that—"the quantity and vicinity of iron in most ships has an effect in attracting the needle; for it is found by experience that the needle will not always point in the same direction when placed in different parts of the ship; also, it is rarely found that two ships steering the same course by their respective compasses will go exactly parallel to each other; yet these compasses, when compared on board the same ship, will agree exactly.

In 1801 Captain Flinders, of H.M.S. Investigator, found, by a series of observations taken by the same compass in different parts of the ship, that a change of place from the binnacle to a little before the centre of the ship produced a difference of $4\frac{1}{2}°$ in the mean variation; and on his return to England in 1810, the Admiralty, in consequence of his representation, directed a series of experiments to be made at Sheerness on board several of H.M.'s ships: the resulting report contained some sound principles, but was based on too few observations and too limited conditions to be generally applicable.

Flinders dying soon afterwards, the subject received little attention till 1817, when Mr. Bain, a master in the royal navy, published a valuable little essay on the variation of the compass. Shortly after, in 1819, Professor Barlow engaged in an extensive course of experiments, with a view of discovering some principle of computation or correction for this source of error. After many investigations which will be found published, he proposed, by means of a circular disc of iron placed near the compass, to counteract the effect of the large masses of iron lying before and below the horizontal plane of the compass. This mode of correction was successful at the time, but on the application of so much wrought-iron in the structure of ships, particularly the machinery of steam-vessels, conditions arose which rendered the compensation by one plate of iron of a certain degree of hardness uncertain in its results; the correcting plate has therefore fallen entirely into disuse.

The introduction of iron-built vessels, some twelve to fourteen years after Professor Barlow's investigations, and the then existing doubts as to the possibility, or at least the security, of their navigation from the presumed powerful magnetic action on the compass, gave increased interest to the subject; and we accordingly find that in 1835 the late Captain Edward Johnson of the Royal Navy, (the former Superintendent of its Compass Department,) undertook by direction of the Admiralty a series of experiments in the iron ship Garryowen of 281 tons burden, lying in the river

Shannon, with a view to ascertain the best position for the compass, as also the applicability of Barlow's plate.

It was then observed that the vessel acted as a permanent magnet on the compass and other magnetic instruments placed *exterior* to the vessel, and also that Barlow's plate failed as a corrector under the novel condition of its trial. Captain Johnson's paper and experiments in detail will be found among the *Philosophical Transactions* of the Royal Society for 1836.

In 1838 Mr. G. B. Airy, the present Astronomer Royal, also by the desire of the Board of Admiralty, conducted a series of experiments on board the iron vessels Rainbow and Ironsides, with a view to discover the laws of magnetic disturbance These experiments further determined that the *interior* of an iron vessel acted upon the compass as a permanent magnet. The results, accompanied with elaborate investigations, are published in the *Philosophical Transactions* for 1839, and a popular account of the same experiments, and deductions therefrom, were afterwards given by Mr. Airy in the *United Service Journal* for 1840, and also separately published by Mr. Weale of Holborn in the same year, with practical rules added for neutralizing the ship's disturbing force by the introduction of new and antagonistic disturbing forces in the shape of bar magnets and masses of soft iron.

Mr. Airy resumed the subject in later years, as additional records of observations in various parts of the world came under his notice, and a highly instructive (though in parts necessarily abstruse) paper was communicated to the Royal Society in 1855, and published in their *Transactions* for that year.

Preparatory to entering on the nature of and the laws affecting the magnetism of ships, it may not be considered irrelevant to touch concisely on a few of the general features of Terrestrial Magnetism, and I the more readily invite your attention to it, as bearing directly on the subject under review, and also as being one of those branches of science that should be acquired, at least in its general principles, as a necessary part of nautical education. In support, I may quote from the writings of one of the greatest philosophers of our time (Sir John Herschel): "Among the great branches of science which the present generation has either seen to arise as of new creation, or to spring forward by a sudden and general impulse into a fresh and more luxuriant state of development, there is none more eminently practical in its bearings and application than that of Terrestrial Magnetism."

Magnetism has been happily described as one of those unseen existences which, like electricity and heat, is only known by its effects. The magnetic condition of our globe is manifested at its surface by the three elements known as the Variation, Dip, and Intensity. The two former terms are, however, seldom used in scientific discussions, having given way to the modern appellations of Magnetic Declination and Inclination. The original and more simple names, which are familiar to every sailor, I propose to retain in this paper.

We may define the magnetic Variation as the amount by which the pointing of the compass-needle differs from the true geographical north; the magnetic Dip as the line of inclination to the horizon of a freely sus-

pended needle, not limited in motion only to the horizontal plane, as is the compass-needle; the Intensity as the amount of magnetic force acting on the freely suspended needle, and giving it its direction. This latter element may be resolved into two components, one acting on the horizontal, the other in the vertical direction.

The Variation is in most parts of the globe undergoing continual change, partaking of an annual as well as a diurnal variation. The latter follows a general law in either hemisphere: in the northern, the movements of the north pole of the needle from about 8 A.M. to 1 P.M is from east to west, it then becomes stationary, and with a slow motion retrogades to the east, arriving at the original point about 10 P.M., a smaller oscillation being observed during the night; the movement in the southern hemisphere is reversed in direction. The amount in angular value varies in different latitudes, and according to the seasons; in northern Europe it attains 15′ or 17′.

The annual change varies in different regions; at the present time (1859) in Great Britain the average decrease is about 6′. On the eastern coasts of America, nearly in the same parallel, it appears to be increasing by a similar amount.

I may take this opportunity of submitting for your examination a Variation Chart of the World,* which has engaged my attention for several months, and which has just been published by the Admiralty. It results from numerous observations made by the officers of H. M. navy, chiefly between 1850 and 1858, also from various magnetic surveys undertaken by the British and Foreign Governments.

The dip of the magnetic needle engages but little the attention of seamen, though it is familiar to them that the compass-needle does not retain its horizontality on great changes of latitude, excepting through the medium of adjusting-weights. As the dip is an important element in the consideration of the changes of the magnetic condition of all vessels, but especially of iron ships, a brief account of its nature and distribution is necessary. The term magnetic poles is generally applied to those positions on the surface of the earth where the horizontal force disappears, and a freely suspended needle becomes vertical; the same end of the needle pointing in opposite directions in either hemisphere. In like manner the term magnetic equator is applied to those places where the needle has no inclination or dip, but rests in an horizontal direction: this line of no dip is irregular, and of double flexure, cutting the geographical equator in four points, and inclined to it generally at an angle of 12°.

The dip increases gradually on either side of the magnetic equator, and the lines of equal amount are nearly parallel to it till within the vicinity of the magnetic poles. A ship sailing along one of the lines of equal dip, is said to remain in the same magnetic latitude, and she changes her magnetic latitude most rapidly when her course is at right angles to those lines. The dip, like the variation, is subject to secular change; the annual decrease in the British Islands, and over a great part of Europe, has averaged, for several years past, about 3′; in the South Atlantic Ocean it is increasing about 6′ annually.

* Presented to the Library of the United Service Institution.

The intensity, in a philosophic point of view, is the most interesting element of terrestial magnetism, as from its general investigation fruitful results in respect to the theory are anticipated; and it is practically useful for the seaman to know that the magnetism of his ship may be proportionally affected according to the regions of greater or lesser intensity passed through.

An ordinary and simple method of determining the intensity, is by vibrating a freely suspended dipping needle, which is acted on by the magnetic force of the earth in a similar manner to that in which the pendulum is acted on by gravitation: the squares of the number of vibrations in a given time at various places give the ratio of the intensity at those places. By the application of a more refined and difficult method, the absolute values may be determined; these values may be defined as a series of numbers representing the ratio of intensity to a given unit for every point of the earth's surface, and are represented on a chart by lines of equal value (*isodynamic* lines), similar to the variation chart submitted for your inspection.

An investigation of the lines of equal intensity tends to these results, viz., of there being two foci, or points of maximum force, in either hemisphere. These foci are of unequal force: the greatest in the northern hemisphere is in North America, the weaker in the north of Siberia: the corresponding phenomena in the southern hemisphere are not determined with the same precision, but appear to have the same general characteristics. As a general rule, the magnetic intensity is least near the equatorial portions of the globe, and greatest in the polar—the vicinity of St. Helena appearing to have the smallest amount yet discovered.

Having thus noticed those elements of terrestrial magnetism necessary for a correct appreciation of our subject, we may now enter on the consideration of the theory of the magnetism of ships:—The errors of the compass on board ships arise from two distinct sources of magnetism; the one transient, induced in the soft iron of the vessel; the other permanent, originating in the rolled and hammered iron (differing from the condition of soft iron) employed in the construction of the hull and machinery.

Induced magnetism is due (1st) to the magnetic action of the earth, whereby every particle of "soft iron" is converted into a magnet, whose direction is parallel to that of the dipping needle, and which magnetic power it loses on removal from that influence; and (2dly) when exposed to the influence of any magnetic body, which induced magnetism it loses when the influencing body is removed.*

By permanent magnetism is understood the property of attraction and repulsion belonging to a mass of hard magnetized iron, whatever may be its position; thus differing from induced magnetism, which, as stated, (1st) only acts in the line of the dip. "Hard iron" does not under ordinary circumstances become magnetic by induction; but when mag-

* The action of the earth on the north end of the needle is exerted in the direction which is called the *line of force*. This is the direction of the dipping needle, viz., towards the magnetic North, but inclined to the horizon at an angle equal to the magnetic dip, at the place—in England about 68° below the horizon. A bar of soft iron held in the direction of the line of force of the earth becomes instantly magnetic.

netized it retains the magnetic power even after the influencing body is removed, thus also differing from the induced magnetism of "soft iron," (2dly), which vanishes directly the influencing body is removed.

We have now to consider the action of induced and permanent magnetism separately on the compass-needle, and which can be illustrated practically by using iron bars of either quality. Employing a hard iron bar magnetized, and placing it in a direct line north or south of the compass-needle, with that end which attracts the north end of the needle being placed nearest the centre of the needle, it will be found to produce no deviation; when due east of the needle (as disturbed) it will cause a maximum easterly, and when west, a maximum westerly, deviation.

Note.—If we project the curve resulting from this experiment on the face of a compass-card, or from a straight line divided into 32 points, it will assume the form of figures 2 and 2'. (Plate I.)

The effect of a bar of soft iron on the compass-needle is more complicated, depending (1st) on the direction and amount of the dip at the place of observation; (2dly) on whether it is placed in a vertical or horizontal direction. In north magnetic latitudes, if placed in a vertical position, the upper end attracts and the lower end repels the north point of the needle; in south magnetic latitudes the reverse occurs: on the magnetic equator where the dipping-needle assumes a horizontal position, the vertical bar of soft iron will cease to be magnetic. The effect on the compass arising from this vertical portion of the earth's induction on soft iron is so far the same as that arising from the permanent magnetism of hard iron as to attract the north end of the needle as the ship swings round; but with a varying amount of attractive power proportional to the tangent of the dip, which latter magnetic element, as is generally familiar to seamen, rapidly alters in passing from north to south, or *vice versâ*, over the globe; whereas the attractive force of the permanent magnetic bar varies in an inverse proportion to the horizontal magnetic intensity, and diminishes therefore for example between England and the Cape of Good Hope in the proportion of 20 to 16. This part of the deviation arising from the combined effects of permanently magnetic iron and of magnetism induced in soft iron by the vertical part of the earth's force, is termed by Mr. Airy "polar-magnet-deviation."

The nature of the change in the deviation produced by the permanent and induced magnetism respectively, on a change of magnetic latitude, is thus described by Mr. A. Smith, a high authority on magnetic science—

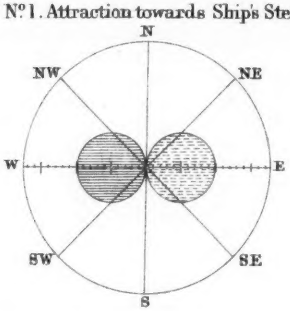
The first varies inversely as the horizontal force; the second varies as the tangent of the dip; their changes in different magnetic latitudes may be thus described: at a magnetic pole of the earth when the dip is 90°, and the horizontal force zero, each part becomes infinite:—this indicates that there is then no directive force.

For some distance from the magnetic pole, the two parts change nearly at the same rate, and therefore the whole varies nearly as the tangent of the dip; but as we approach the magnetic equator, the part which arises from the soft iron diminishes the most rapidly. It becomes zero at the equator, and in south magnetic latitudes has the same value as in corresponding north magnetic latitudes, but the opposite sign. The part which arises from the hard iron does not become zero at the magnetic equator, but becomes a minimum at that line, nearly coincident with the magnetic equator, at which the horizontal force is a maximum, and in south magnetic latitudes it has the same sign and nearly the same value as in northern.

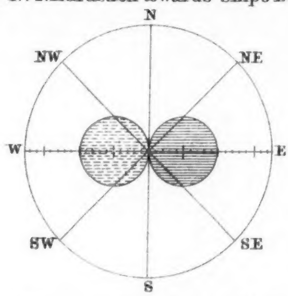
POLAR DEVIATIONS — As these vary as the sines of the angles of ship's force with direction of disturbed compass, circular curves are obtained.

QUADRANTAL DEVIATIONS — As these vary as the sines of twice azimuth of ship's head by disturbed compass, oval or looped curves are obtained.

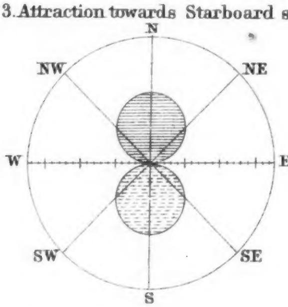
Nº 1. Attraction towards Ship's Stern.



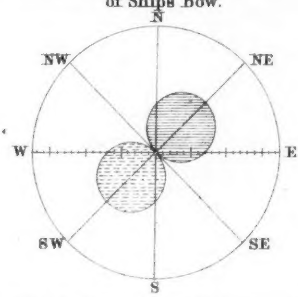
Nº 2. Attraction towards Ship's Bow.



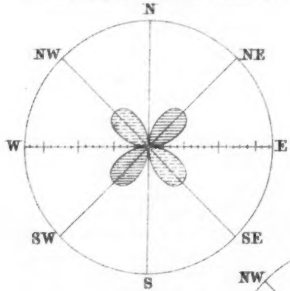
Nº 3. Attraction towards Starboard side.



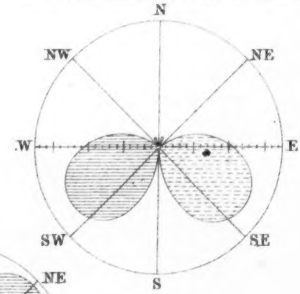
Nº 4. Attraction four points to Starboard of Ships Bow.



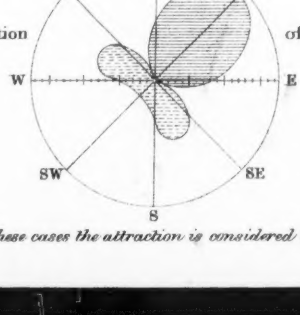
Nº 5. Plus Quadrantal Attraction.



Nº 6. Combination of Nºs 1 and 5.



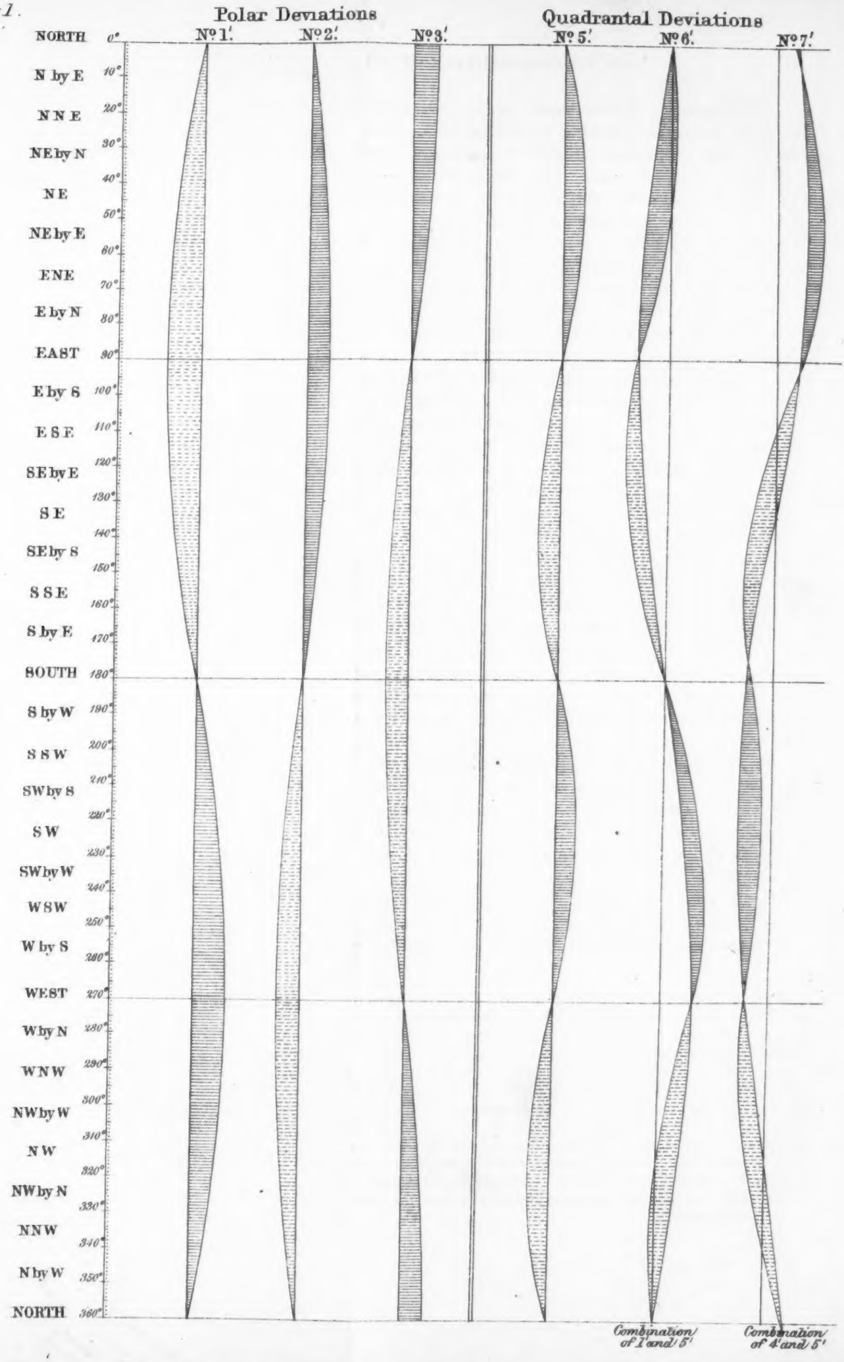
Nº 7. Combination of Nºs 4 and 5.



Note. *In all these cases the attraction is considered to be on the North end of the needle.*

NORTH
N by E
N N E
NE by N
N E
NE by E
ENE
E by N
EAST
E by S
E S E
SE by E
S E
SE by S
S S E
S by E
SOUTH
S by W
S S W
SW by S
S W
SW by W
W S W
W by S
WEST
W by N
W N W
NW by W
N W
NW by N
N N W
N by W
NORTH

late 1.



Polar Deviations
Quadrantal Deviations
Nº 1.'
Nº 2.'
Nº 3.'
Nº 5.'
Nº 6.'
Nº 7.'
NORTH
N by E
N N E
NE by N
N E
NE by E
ENE
E by N
EAST
E by S
E S E
SE by E
S E
SE by S
S S E
S by E
SOUTH
S by W
S S W
SW by S
S W
SW by W
W S W
W by S
WEST
W by N
W N W
NW by W
N W
NW by N
N N W
N by W
NORTH
0°
10°
20°
30°
40°
50°
60°
70°
80°
90°
100°
110°
120°
130°
140°
150°
160°
170°
180°
190°
200°
210°
220°
230°
240°
250°
260°
270°
280°
290°
300°
310°
320°
330°
340°
350°
360°
Combination of 1' and 5'
Combination of 4' and 5'

A horizontal bar of soft iron placed at the same level as the compass-needle, and in the same fore and aft line, produces a deviation as the ship swings round which has been termed by Mr. Airy "quadrantal," from changing its character in each quadrant of the compass: thus, an easterly deviation occurs when the ship's head is between north and east; westerly when between east and south; easterly deviation again between south and west, and westerly with the ship's head in the remaining quadrant: the maximum amounts of deviation being at N.E., S.E., S.W., and N.W., and the points of no deviation at north, south, east, and west. The reason of this action is readily explained: when the bar is at right angles to the magnetic meridian, or in a direction east and west to the line of the keel when north and south, it ceases to be magnetic; in any other position its south end attracts the north end of the needle and its north end repels it. But if the bar be placed in the line of the keel with the ship's head north and south, though it attracts the needle, it does so in the direction in which it points, and therefore produces no deviation: the chief action is therefore on the intermediate points.

Note.—By projecting the curve resulting from the experiment as just described, it will assume the form of fig. 5. Plate I.

It is especially worthy of note that the quadrantal deviation of the compass resulting from the combined action of the fore and aft horizontal portion of the soft iron in the ship is independent of locality, remaining the same in all magnetic latitudes.

Having laid before you the characteristic qualities of permanent and induced magnetism, it is now necessary to consider their combined action:—if the magnetism of a ship was due entirely to the action of "soft" iron and "hard" iron, it would be possible by observations made in any two magnetic latitudes to determine the values of their parts separately; or theoretically from observations in the one geographic position to deduce the values in any other, as their laws of change have been fully investigated. But it will readily be conceived that a large portion of the iron entering into the composition of a vessel must vary in its nature between the extremes of "hard" and "soft." The magnetism of this iron in an intermediate state has been named "subpermanent," or "retentive;" and it is from the combination of the permanent and induced being apparently so inextricably mixed up that to determine the value of the two portions separately by theory appears impossible. Other features also present themselves, for it is considered that the conditions of subpermanent magnetic iron are liable to change from blows or straining of the vessel; and General Sabine has pointed out in his valuable contributions to Terrestrial Magnetism, No. IX., (see *Philosophical Transactions* for 1849,) that the changes of magnetism corresponding to changes of the ship's place are gradual rather than instantaneous, or in other words that this portion of the magnetism depends not only on the place where the ship is, but where she has been for some preceding days or weeks.

Bearing the foregoing laws and facts in view, it will be understood how the deviations of the compass vary in character in different vessels on changes of geographic position:—In wood-built vessels, and especially

sailing-ships, where soft iron predominates, the changes are due to induced magnetism; hence the deviations diminish as the magnetic equator is approached, and change their direction on passing into a south magnetic latitude.

In iron-built vessels where permanent and subpermanent magnetism predominates, the changes of deviation are less regular, and the deviations may retain the same direction in both hemispheres. This is fully exemplified and borne out by examinations I have made of the numerous Tables of Deviations annually transmitted from H.M. ships.

For many years the Admiralty have published Practical Rules for ascertaining the deviation of the compass caused by the ship's iron, and which are doubtless familiar to most or indeed all naval officers. In 1851 the Hydrographic Office published the first, and in 1855 the second edition of a supplement to these practical rules. This useful and highly interesting little work (a portion of which I propose especially to bring to your notice) is supplied to H.M. Ships. The maritime profession is indebted to Mr. Archibald Smith, M.A., F.R.S., of Lincoln's Inn, and late fellow of Trinity College, Cambridge, for this highly valuable contribution to navigation.

The part I wish to allude to, is an instructive process to analyse numerically the various portions of a ship's magnetism due to the laws already explained, by which we are enabled to enter on an investigation of, and generally to account for, any peculiarities in the deviations of the compass of particular ships.

A deviation table having been formed by any of the processes now so generally understood, either on the thirty-two points of the compass, the sixteen intermediate, or the eight principal points—the values of five separate coefficients are deduced therefrom by the aid of mathematical formulæ, which latter have been much simplified in practice by neat tabular arrangements, appended blank forms, and with clear examples.

The five coefficients are distinguished by the letters A, B, C, D, E, and represent the values of the magnetic disturbance for each compass.

D and E are termed the "permanent coefficients," as they are presumed to preserve their values unchanged in all parts of the globe.

B and C are coefficients which change on a change of geographic position, especially of latitude, and it is considered in a way generally impossible to be predicted, and as also to change from extraneous causes.

It is important to describe these coefficients in detail:—The coefficient A is a constant error, it includes any correction which may be due to index error of the standard compass, or the shore compass employed in observing the deviations, or to—a not unfrequent cause of error—the lubber-line of the former not being exactly fore and aft: whatever portion is due to magnetism arises from a peculiar non-symmetrical arrangement of soft iron in the immediate vicinity of the compass only likely to occur in small vessels. This coefficient is in general small: + sign denotes the easterly deviation is in excess; — sign the westerly in excess.

D and E are due to the "quadrantal" effects of the horizontal parts of the soft iron:—the values of D are from that portion acting in the fore and aft or athwartship lines; + sign is due to masses before or abaft the com-

pass; — sign to masses on starboard or port side:—the values of E are from masses of soft iron in the intermediate angles.

D has in general a positive value, and is large in amount, varying from 2° to 5° in most iron vessels. E is in general very small.

B and C, the changing, and generally the largest coefficients, are due to the combined effects of the permanent magnetism of the hard iron, and that induced by the vertical part of the earth's force in the soft iron, of which the separate laws of change have been already described:—B represents that part of the combined attraction acting in a fore and aft direction, + if before the compass, *i.e.* the north end of the needle is drawn towards the *bow*; — if abaft it, *i.e.* the north end attracted towards the *stern*. C that portion acting in an athwartship direction, + if north end of needle drawn to starboard, — if north end of needle drawn to port.

Not the least valuable part of a knowledge of the five coefficients is, that a table of deviations can be constructed from them, by which, whatever original errors of observation may have existed on few or many points of determination, these errors are then divided over the whole thirty-two points of the compass.

In illustration of the principles of a ship's magnetism, and the value of this numerical analysis in determining its character, the case of H.M.S. Sanspareil, of 71 guns, is deserving attention: the funnel of this ship is on the quarter deck, and distant from the standard-compass in its usual position on the break of the poop only 19 feet 4 inches; consequently there must be a lively affinity between them. In the Sanspareil's early equipment the funnel was of copper, and the deviations were small in amount, not exceeding 6°. In 1856, an iron funnel was substituted, when the maximum deviation in England amounted to 24°.

In the voyage to the Cape of Good Hope, Captain Key observed the deviations to alter considerably, and on arrival in port the ship was reswung, and the deviations found to have decreased to a maximum of only 4°.

This was unquestionably a striking change, and in less careful hands might have been a source of much embarrassment. In an interesting letter to the Hydrographer calling attention to the subject, (which will be found in the Nautical Magazine for October, 1857,) Captain Key considers that the deviation of the needle is due only to the induced magnetism of the iron on board, and that its direction is regulated by the position of the poles of that iron.

By employing Mr. Smith's formulæ, we are better enabled to judge of the general character of the magnetism of the Sanspareil, without risking any hypothetical opinions.

Computing the coefficients from the Sanspareil's deviation tables observed in England and at the Cape of Good Hope, with the funnel down, (which brought it nearly on a level with the compass-needle,) we have the following results:—

	A	B	C	D	E	Dip.	Nat. Tang.	$\frac{1}{\text{Hor. Force.}}$
	° ′	° ′	° ′	° ′	° ′	° ′		
Plymouth	+0 4,	+23 43,	+1 45,	+0 58,	−0 13,	68 40+,	2·60.	2·04
Cape of Good Hope .	−0 37,	+ 3 41,	+2 08,	+1 16,	+0 36,	54 00−,	1·38.	1·66

Here it is obvious that the permanent coefficients may be considered —

taking into account the probable small errors of observation—to have stood the test of theory, and that the effect on the changing coefficients is due to the combined action of permanent or polar-magnet deviation and induced magnetism. Were the deviations of the Sanspareil's compass due alone to the induced magnetism of the funnel and guns as surmised by Captain Key, the cofficient B would have differed from the amount in England (+23° 43′) in the proportion of the tangent of the different dips, or as 2·6 to −1·4, giving a result of −18° 45′ instead of +3° 41′. Were they due to permanent magnetism alone, B would have differed from its amount in England in the proportion of 2·04 to 1·66 (values deduced from Gauss's chart of magnetic intensity) giving a result of +18° 58′ instead of +3° 41′. As the value of B deduced from the observation at the Cape, viz. +3° 41′, lies between the two values above deduced, we may infer that the polar-magnet deviation was caused in nearly equal proportions by the permanent or subpermanent magnetism and the induced magnetism.

The accompanying coefficients of two wooden sailing vessels, and two iron steam-vessels, as computed from observations made in England and at the Cape of Good Hope, are instructive examples of the changes according to the theory advanced.

H.M.S. Herald (Surveying Ship).

	A	B	C	D	E
	° ′	° ′	° ′	° ′	° ′
River Thames, May, 1852	×0 5,	+2 6,	−0 7,	+0 15,	0 0
Cape of Good Hope, Nov. 1852 .	−0 13,	−1 45,	0 0,	+0 9,	+0 15,

H.M.S. Mæander (40 guns).

	A	B	C	D	E
Sheerness, September, 1852 . . .	−0 15,	+1 10,	+ 0 30,	−0 15,	+0 8
Cape of Good Hope, March, 1853	−0 23,	−2 35,	− 0 3,	−0 10,	+0 6

H.M.S. Simoom (Iron Troop Ship).

	A	B	C	D	E
Portsmouth, September, 1852 . .	−0 7,	+20 07,	− 7 18,	+4 33,	−0 19
Cape of Good Hope, Oct. . 1853	−1 47,	+13 06,	− 2 23,	+4 13,	+0 22

H.M.S. Vulcan (Iron Troop Ship).

	A	B	C	D	E
Portsmouth, July, 1852	−0 13,	− 8 47,	+0 43,	+3 37,	−0 44
Cape of Good Hope, Feb. 1853 .	+1 8,	−16 3,	+1 19,	+4 15,	+0 51

On Deviation Curves.

Graphic projections of the deviations of the standard compass are not only useful in practice, but serve as a simple and ready mode of obtaining a table of probable deviations for every point of the compass from observations made on a few points only, and particularly for illustrating the nature of the ship's magnetism, whether polar-magnet, or quadrantal, or the two combined. The earliest in point of date will be found in the supplement to the Admiralty Practical Rules, and is due to Mr. R. J. Napier of Glasgow; the second by Captain A. P. Ryder, of the Royal Navy, is similar in principle, though simplified for seamen in a part of its application; and the third, designated the "straight line method," is due to

Mr. A. Smith, F.R.S., and appended to the Board of Trade instructions for correcting the deviations of the compass.

The chief object of Mr. Napier's method is to determine the amount of deviation for each of the 32 points of the compass, from observations made on a few detached points (without entering into the diffuse calculations otherwise necessary), by tracing a curve deviating more or less from a straight line, which may be considered as the margin of a compass-card, cut at the north point and straightened:—the difference between the curved and straight lines gives at once a clear idea of the amount and character of the disturbing effects of the ship's iron. The exact conversion of compass courses into correct magnetic courses, and *vice versâ*, follows as an invaluable part of the method.

Captain Ryder's plan has more particular application to the conversion of courses, as, from mere inspection of the curves of deviation as drawn on his projection, correct magnetic or standard-compass courses and bearings can be at once obtained, and with little possibility of error. Mr. A. Smith's straight-line method will also be found a simple and convenient plan for tabulating the results of the observations, and of making the "course" corrections.

Captain Nolloth, of the Council of this Institution, has also exhibited before you and explained a Deviation Diagram; it is given in the first volume of the Journal of the Institution, accompanied with these remarks: "It appears that by this method of graphical delineation a convenient means is afforded of comparing various forms of deviation curves, and of considering them in connection with the circumstances of magnetic influence under which they respectively occur."

In the accompanying diagrams, Plate I. projected both on Captain Nolloth's circular plan, and a simple adaptation of Mr. Napier's method, you will readily distinguish the characteristics of polar-magnet deviation (*i.e.* permanent magnetism and vertical induction) and quadrantal deviation; but it must be recollected that practically these two are combined in every variety of manner.

The easterly deviations are denoted by *hatched* lines, the westerly deviations are denoted by *dotted* lines.

Fig. 1 and 1′, represents polar deviation alone, where the attraction is towards the ship's *stern*.

Fig. 2 and 2′, polar deviation alone, where the attraction is towards the ship's *bow*.

Fig. 3 and 3′, polar deviation alone, where the attraction is towards the ship's *starboard side*.

Fig. 4, polar deviation alone, where the attraction is 4 *points on starboard bow*.

Fig. 5 and 5′, quadrantal deviation (+) giving easterly deviation in the N.E. and S.W., and westerly deviation in the N.E. and S.W. quarters. Fig. 6 and 7 and 6′ and 7′ are combinations of the polar and quadrantal; fig. 6 being 1 and 5 combined, fig. 7, 4 and 5 combined. In these two latter diagrams on Napier's method only the quadrantal excess or deficiency has been tinted.

I have now to bring to your notice, and under review, the valuable

labours, still in progress, of a Committee formed at Liverpool by various gentlemen connected with the vast shipping interests of that port, and working also under the auspices of the Board of Trade, to collect observations and make experiments on the condition and distribution of magnetism in iron-built ships, and the general system of compass correction and management.

Two or three disastrous shipwrecks, clearly traced to compass errors, occurring about the time that the iron navy of Liverpool was rapidly expanding, gave rise to various conflicting opinions on the safety of their navigation, and particularly on the subject of compass-compensation by magnets; these questions were discussed in various periodicals, and also at the British Association for the Advancement of Science, held at Liverpool in 1854: hence arose the formation of the Liverpool Compass Committee.

The publication in 1857 of the First and Second Reports of that body to the Board of Trade, and presented to both Houses of Parliament by command of Her Majesty, enables the observations relative to the theory of the magnetism of ships to be extended, not only in confirming what has been already advanced, but in giving some more general views of its character and distribution, particularly in iron-built vessels.

A striking feature in these Reports is, that the researches of the various authorities already quoted, and their exposition of the laws of magnetic action on ship-board, have received ample confirmation from the various observations collected and experiments undertaken by the Committee. In the opening page of the Second Report they observe, that it has been "proved, too, most decisively, that the deviations of the compass on board iron ships, when properly ascertained, are not of that irregular and erratic character which many cards of deviation might lead one to suppose, but that they accord most closely with the deductions of theory and experiment, as exemplified in the works of the Astronomer Royal and Mr. Archibald Smith." And again, at p. 24, in alluding to certain fluctuations in the amount and direction of a ship's induced magnetism,—"These fluctuations do not appear, however, to affect *practically* an authoritative statement which has already been supported by the Committee, and which, as it forms the key to the correction and calculation of compass deviations, cannot be too earnestly repeated; namely, that a ship's magnetism for any given place may be very closely represented by a permanent polar magnetic force in combination with a quadrantal force, or one changing its deviation in each quadrant as a ship is swung round."

Among the various philosophers who, during the present half century, —a period noted for the progress of theoretical and experimental research— have grappled with the perplexing and it may be said uninviting science of magnetism, none more perseveringly worked for practical ends than the late Rev. Dr. Scoresby, and to him is due the enunciation of the notable facts, that the distribution of magnetism in an iron ship depends on the direction of the keel and head while building with reference to the magnetic meridian; and that this original magnetism is subject to great changes after launching, and also from other extraneous causes. The following from among the results of his investigations, as bearing on the subject, are worthy of extract.—(*Magnetical Investigations, by the Rev.* WM. SCORESBY, D.D., vol. ii. 1852, pp. 330—343.)

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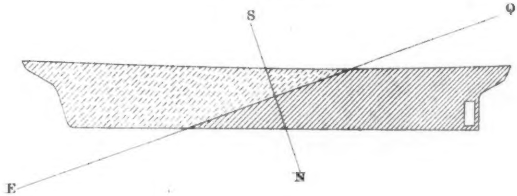
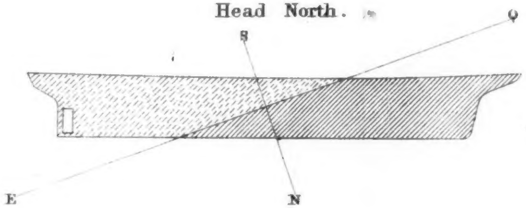
THEORETIC MAGNETIC CONDITION OF IRON SHIPS BUILT IN ENGLAND WITH THE DIP OF THE NEEDLE FROM 68° TO 70° NORTH, PREVIOUS TO BEING LAUNCHED.

(according to the late Dr. Scoresby)

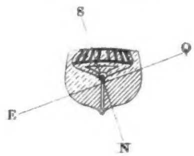
Head South.



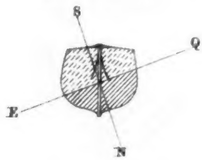
Head North.



Head West.



Head East.



The axial line S.N. in each figure represents the direction of the Dip or line of magnetic force as passing through the general centre of gravity of the material of the ship.
All below the equatorial line E.Q. shaded with firm lines has Northern polarity; all above it, shaded with dotted lines, has Southern polarity.

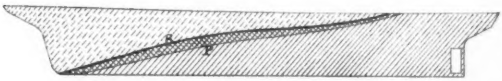
TH

MAGNETIC CONDITION OF VARIOUS IRON SHIPS RESULTING FROM ACTUAL EXPERIMENT AS DETERMINED AT LIVERPOOL BY THE COMPASS COMMITTEE.

1856-7

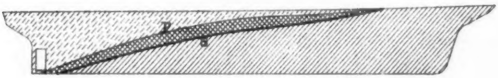
Bœotia.

Built head to South (a little West)



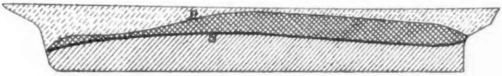
City of Washington.

Built head to North



Sarah Palmer.

Built head to East (a little North)

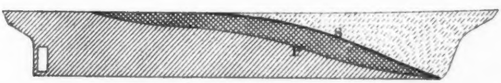


Borysthene.

Built head to N.E.

Barcelona.

Built head to S. W.



Note. *The letters* P *and* S *denote the Port and Starboard lines of no Deviation.*

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1. That ships built of iron, in place of timber and plank, obtain necessarily *an extremely high degree* of magnetic development from the elaborate system of percussive action, as well as from the bending of the plates and bars, during the progress of their construction.

2. That the dominant magnetism thus developed is of the *retentive quality*, a quality remaining whilst terrestrially sustained by consistency of position, and otherwise, also, in relations inaccordant with terrestrial influence, whilst the ship remains free from mechanical violence or other magnetically disturbing force.

3. That in each iron ship there is a special individuality of the magnetic distribution, depending *essentially* on the position—characterised by the direction of the keel and head—whilst building, and *peculiarly* on the deviations from uniformity in the placing of occasional heavy masses of iron.

4. That, after being launched, percussion, vibration, or the straining of the general frame of iron-built ships, must *tend* to equalise the relations of the ship's magnetisms with with those of the earth; and that the state of equalisation, or approximation thereto, will be hastened and advanced, accordingly as the quantity or intensity of mechanical violence is increased, and accordingly as the ship's head is kept pretty steadily in the same direction.

The accompanying diagrams (Plate II.) represent, according to Dr. Scoresby, the theoretic magnetic condition of iron ships built in England, with the dip of the needle from 68° to 70° N., previous to being launched.

The confirmation of Dr. Scoresby's views will be seen from the following extract. "The records of the Committee no longer allow a doubt as to the connection which exists between the direction of a ship's original magnetism and her position when upon the building slip. In all the ships which have been examined, the north end of the compass-needle invariably deviated towards that part of the ship which was farthest from the north while she was building, if the compass was placed in a central position, and free from the influence of individual masses of iron."*

The Reports also further proceed to show that the characteristic features of the original magnetism of an iron ship, by which is meant the magnetism dependent on her direction when building, and the effect on a compass when she is swung, presuming that the needle is not influenced by iron bulk-heads, or proximity to the stern-post, rudder-head, or other masses of vertical iron controlling the magnetism of the hull of the ship, is as follows:—

In an iron ship built with her head to the north, or nearly so, there is no apparent attraction of the needle towards either side while she lies in a north or south direction: but with her head in all other directions there is a strong attraction towards the stern.

With ships built head to the south, the same principle will apply, the deviation being then towards the bow.

When built with head to the east, the deviation is towards the starboard side, (the south in building) and when built with the head to the west, to the port side, (the south in building): [this deviation must be considered as only due to a differential action, for if a compass be placed near the top sides of such ships either internally or externally, the north end of the needle (in north magnetic latitudes) is attracted; one side however attracts the needle more strongly than the other, and that is the side which was

* This is exemplified by the diagrams Plate 2. which represent the magnetic character of various vessels as determined by actual experiment at Liverpool while they were in dock.

furthest from the north when the ship was building, as above stated.] In these vessels if placed in an east or west direction, the north end of the needle will tend to the bow or stern respectively according to the direction in which lies the greater mass of iron.

In ships built in intermediate positions the preceding characteristics are combined; thus, if built with head to the N.E., the attraction will be aft and to starboard; with the head to the N.W., aft and to port. If the head be S.E. or S.W., the attraction will be forward and to starboard, or forward and to port respectively.

The *amount* of original magnetism appears to have relation to the size of the vessel, or the quantity of iron used in her construction, and is thus illustrated:—"In a ship of 400 tons, built head to east, if a compass be carried fore and aft on the middle line, about three or four feet from the deck, the deviation may be 10° or 12° when her head is north or south. In a ship of 1,000 tons it may under the same conditions be 25° or 30°, or more, depending to some extent on the breadth of the ship."

From a consideration of the foregoing illustrations, we may at once predicate the character of an iron ship's deviation from a knowledge of the direction of her keel and head when building, or, *vice versâ*, from having her deviation table we may infer the direction in which she was built: the accompanying table illustrates generally these conditions. Thus if

Approximate direction of ship's head (magnetic) while building is,	Maximum Easterly deviation when ship's head is near.	Maximum Westerly deviation when ship's head is near.
North.	West.	East.
N.E.	N.W.	S.E.
East.	North.	South.
S.E.	N.E.	S.W.
South.	East.	West.
S.W.	S.E.	N.W.
West.	South.	North.
N.W.	S.W.	N.E.

We have now arrived at an important feature of the inquiry—the alteration in the ship's magnetism after launching—and which would still appear to require an extended series of experiments to elicit more precise information. Numerous examples are given by the Committee, but derived more from information communicated than from direct experiment; still there is a notable example deduced from the latter in the case of the ship Royal Charter, which will be hereafter alluded to. The conclusions arrived at are thus given:

This original magnetism of an iron ship is frequently very permanent as regards direction, but is believed to undergo rapid changes in its amount, both in reality and in its apparent effect on the compass: the most striking change being at and immediately after launching, and during the first voyage. It is usually more evident in a steamer than in a sailing vessel. There are cases in which the deviations in a steamer have changed so much as two points in the first two days at sea, while afterwards the change has not been more than 3° in as many months. In new sailing ships the change is generally, but not always, more gradual, and extends over a longer period. A change of 10° to 15° is not infrequent.

Again, Under some circumstances considerably more than one half of a ship's original magnetism, or rather that part of it which affects the compass, may be lost, or may become balanced in the course of a year.

And, After this early reduction of a ship's magnetism has taken place, the remaining portion, as far as may be judged from examinations made in the same place, and under the same circumstances, appears to be comparatively permanent.

In confirmation of this comparatively permanent condition of a ship's magnetism the Committee give a striking example in the case of the ship Great Britain; and it may be permitted me to express my opinion, having had the opportunity of inspecting deviation tables of most of the iron vessels in H.M. navy, extending over many years' observations, that from this evidence also their permanent condition appears to be the rule.

The Committee thus report on that well-known iron ship the "Great Britain:"—

This extraordinary ship has been stranded, and strained, and altered; has traversed both hemispheres, and been very many years in active service: yet her lines of no deviation are now much the same as Dr. Scoresby would indicate them to have been when she was upon the stocks. Yet how small is the change! a proof, apparently, that no circumstances can permanently *conceal* or greatly alter the direction of an iron ship's original magnetism.

[Illustrations in support of these views are given in the Committee Reports of the lines as taken in a graving dock, January, 1856; again in December, 1856, after being for some weeks head N.N.E. in the same graving dock: as they appeared two days after with her head in the opposite direction; and again as determined twice in January, 1857, after undergoing constant hammering in almost every part for forty-three days.]

The most instructive case of the rapid changes of magnetism in a newly-built iron ship is illustrated in the case of the ship Royal Charter, whose deviations were carefully obtained prior to leaving England in January, 1856; at Melbourne in Australia, in May, 1856; and again on her return to Liverpool in August of the same year. These changes are well exemplified by a comparison of the values of the five coefficients alluded to; the results being selected from an extended series of observations, as made with an Admiralty standard-compass specially placed in aid of the experiments.

	A	B	C	D	E
	° ′	° ′	° ′	° ′	° ′
At Liverpool in Jan. 1856, previous to going on first voyage	−0 27,	−3 48,	−19 42,	+6 59,	−0 52
At Melbourne in Australia, May, 1856 .	−1 27,	−1 11,	− 8 59,	+6 23,	−0 16
At Liverpool on return, in August, 1856	−0 3,	−1 6,	− 3 22,	+6 10,	+0 56

We see here very distinctly the permanency of the quadrantal deviation as represented principally by the coefficient D; and the gradual diminution of the subpermanent magnetism, or polar-magnet deviation, in the coefficients B and C.

Subsequent experiments in the Royal Charter indicate that the subpermanent magnetism is approximating to its original amount; but, as some alterations have been made in the ship's fitments, the comparisons are not strictly identical; they are nevertheless well worthy of attention.

	A	B	C	D	E
	° ′	° ′	° ′	° ′	° ′
Liverpool in September, 1856, after alterations	−0 19,	+1 13,	− 8 33,	+6 0,	−0 19
Liverpool in October, 1856	−0 9,	−4 55,	−14 0,	+6 41,	−0 9

Enough has now been advanced to show the valuable nature of the investigations under review, but on the subject of the changes of original magnetism in newly-launched iron ships there appears to be ample scope for further inquiry, both as to the possibility of there being some regular law of change, as also as to the probable time required for the developement of its final permanency of character. The alarming change alluded to in the Reports by the Committee of "cases in which the deviations in a steamer have changed so much as two points in the first two days at sea, while afterwards the change has not been more than 3° in as many months," is from its amount and irregularity sufficient to embarrass the most careful navigator; it is certainly to be hoped that the cases on which the statement is based are exceptional, and arising from the injudicious selection of a position for the compass (probably from close proximity to some ponderous mass, especially of vertical iron). I am certainly disposed to view them in this light from a consideration of the results obtained in the Royal Charter.

On the Errors arising from the Heeling of Iron Ships.

An important feature in the navigation of iron vessels, and one at the same time of a perplexing character to the navigator, are the changes of deviation of the compass arising from the heeling of some ships.

In wood-built vessels the errors from this cause may be considered as in general too small in amount to be appreciable in practice, unless the compass is in close proximity to the guns or other masses of iron; but in iron-built vessels the results are not unfrequently of sufficient magnitude to call forth unceasing attention and vigilance. Our information on this head is for the present very incomplete; but some few leading points can be traced, sufficient to place the seaman on his guard, and to draw attention to the general characteristics. Messrs. Rundell and Towson, the Secretary and Honorary Secretary to the Liverpool Committee, who have paid great attention to the subject, and made various experiments, are of opinion that heeling affects to the greatest extent ships that are built with their heads to the north or the south; and that the effect on the former is to draw the north end of the needle to the weather side, the deviations reaching their maxima when the ship's head is north or south (by compass), and having little or no effect when the ship's head is east or west. In ships built with their head to the south, the north end of the needle will be drawn to the lee side, the maxima and minima deviations observing also the same conditions as those just described.

I propose now to enter somewhat briefly, as I have trespassed long on your attention, on the vexed question of mechanical adjustment for compasses.

Much controversy has taken place on the propriety and indeed safety of applying an antagonistic force to neutralize that of the disturbing effects of the iron in the ship: our highest magnetic authorities differ on the point, though agreeing in the main theoretical principles as to the nature of the magnetic disturbances. The Astronomer Royal is strongly in favour of correcting the deviation of the compass by opposing forces of magnets and soft iron. Admiral FitzRoy, General Sabine, and Mr. A. Smith, sup-

ported by numerous nautical authorities, consider such corrections dangerous—except within certain limits, such as coasting navigation—and prefer a superior compass, to be considered a standard, fixed in an elevated position, convenient for careful bearings, as far removed as possible from the disturbing influence of iron, and using the binnacle compass merely as a guide to the man at the wheel.

The opponents of the system of compensation urge that it is defective in principle and dangerous in practice; defective in principle so far, that it has not stood the test of experience in distant voyages to the southern hemisphere, and dangerous inasmuch that it inspires the unskilled and unwary seaman with confidence in the stability of that which is not proved to be stable, and places in his hands a power over the action of the compass-needle, which he cannot control and of whose strength he is ignorant.

The advocates, on the other hand, contend that a fertile source of error in navigation arises from the unskilful use of the deviation tables, the corrections being frequently allowed the wrong way, by which the original error is doubled; also that the tables do not provide for changes of the ship's magnetism caused by change of geographic position, or other circumstances; and again from the want of directive power of the needles under certain conditions of large deviation due to the ship's iron, combined with the earth's directive or horizontal force being small, as in the higher latitudes; which deficiency of directive power, magnet compensation would remedy.

There are just reasons in all or many of these arguments, and the question appears more to resolve itself, as my subsequent remarks will tend to shew, into one of application under varied but certain conditions.

In the Royal Navy, as recommended by a scientific committee of truly eminent men some years since, the system of no compensation is adopted as a general principle: but a rigid adherence to prescribed rules for preserving the compass as free from error as circumstances will permit is enforced—thus no iron is permitted within 14 feet of it, if practicable; and a careful selection of site for each compass in every ship is made under proper supervision. It is accordingly found to result that the amount of deviation in the Royal Navy is in general small comparatively, and that no example of a deviation larger in amount, even in our iron ships (in England) than from 25° to 28° exists, and this only in one or two exceptional cases.

The Mercantile Marine adopts more generally the system of adjustment, and this has led to the introduction of various patented compensating plans, differing widely from the Astronomer Royal's views, based often on no theory whatever, ending frequently in failure, and thus weakening the confidence of the seaman in the compass, and leading him to consider that the magnetism of an iron ship is so capricious as to be beyond all laws and all remedy.

These remarks may not be inappropriately closed by referring to examples of the remarkable want of caution on the part of iron-ship constructors and those engaged in their equipment, evinced in the injudicious arrangements for the compasses given in the Liverpool Compass Committee's Reports. Among the instances quoted will be found the following, "The error in the first position of the binnacle was 101°. As the ship was going to the East Indies, the compass adjuster objected to compensate so large an

amount, and the binnacle was then placed three feet forward; here the error was reduced to two points. In another and much larger ship the compass in the first position of the binnacle deviated 14 points; on moving it a little further forward, the error was reduced to 2½ points." These cases occurred when the original position was selected near the rudder-head of iron vessels, in which a strong attraction existed towards the stern.

It must be evident that under such circumstances of position, no compass, whether compensated or otherwise, can possibly act faithfully, nor can any accurate theoretical deductions be made from such examples; nor, above all, need we be surprised at the serious consequences which too frequently result from dependence being placed on these marvellous mal-arrangements. The Liverpool Compass Committee acted wisely in the promulgation of a circular calling attention to these facts, and expressing their opinion that by attention to the circumstances under which a ship is built, and care in selecting a suitable position for the binnacle, the original error of the compass may be reduced within small limits.

Any observations on the theory of a ship's magnetism would be incomplete without reference to Mr. Airy's method of compensating forces, based as it is entirely on the laws which have been referred to, that is,—

At any place the deviation of the compass in any ship, whether wood-built or iron-built, may be accurately represented as the effect of the combination of two forces, of which one alone would produce a disturbance following the law of polar-magnet deviation, and the other alone would produce a disturbance following the law of quadrantal deviation.

Consequently, at any place the deviation of the compass may be accurately corrected by well-known mechanical methods; namely, by a magnet in the athwartship direction, fixed at a distance determined by trial, for correcting the deviation when the ship's head is north or south: by a magnet in the head-and-stern direction, also at a distance determined by trial, for correcting the deviation when the ship's head is east or west; and by a mass of unmagnetized iron, at the same level as the compass, in the athwartship line or in the head-and-stern line, according to circumstances, (usually in the former,) also at a distance determined by trial, for correcting the deviation when the ship's head is N.E., S.E., S.W., or N.W.

For the same ship, the mass of unmagnetised iron, if adjusted at one port, will produce its due effect at all parts of the world, without ever requiring change or adjustment. The quadrantal deviation may thus be accurately corrected without difficulty, leaving only the polar-magnet deviation uncorrected.*

Mr. Airy's later investigations have led him to consider it desirable that the magnets should be mounted in such a manner that their distance from the compass can be delicately changed, to meet the changes of polar-magnet deviation.

We may expect at no distant period that there will be an accumulation of facts from various parts, particularly from the southern hemisphere, sufficient to prove the accuracy of Mr. Airy's views of compensation under all conditions, and whether its delicate and important manipulations can

* See *Philosophical Transactions* for 1855, Art. V., Discussion of the Observed Deviations of the Compass in several Ships, Wood-built and Iron-built, &c. with a General Table for facilitating the Examination of Compass Deviations, by G. B. Airy, Esq., Astronomer Royal.

be entrusted to all classes of navigators. On one point however mariners may be assured, that at present no other method of compensation has been brought to their notice that has been more elaborately worked out by high scientific and philosophical attainments, or that could equally stand the test of such profound mathematical analysis as has been brought to bear on the subject by the Astronomer Royal.

CAPTAIN NOLLOTH, R.N.—I am sure we must all feel very much obliged indeed to Mr. Evans for his lucid, admirable, Lecture.

There is one observation which I will make, and in which I think you will agree with me, that too much importance cannot be attached to navigators frequently ascertaining the whole error of their compasses, from whatever causes, by celestial observations during the voyage.

If I may hazard a remark concerning nomenclature, I would say that I do not see why we should use the term "deviation" as well as "variation," when the practical results are the same. I remember a man with whom I sailed as a passenger, and who had navigated a ship for some time, allowing the deviation the wrong way, and, when I pointed it out, telling me that he never made a mistake in allowing for the variation, but that he was puzzled now and then with the other. It may appear strange that such a person should ever have been otherwise than puzzled; but there may be others equally troubled. When told that he might consider deviation merely a second variation which had to be allowed for, the thing became clear to him.

MR. EVANS.—I think the term "deviation" is too firmly fixed to be rooted out, though it is a term of the present generation only. The last generation had not iron ships.

CAPTAIN COLLINSON, R.N.—You have elucidated what I may call a somewhat hazy subject, and I have listened with great satisfaction to what you have said, because you have pointed out many things which I was not acquainted with before. I would advise all navigators not to trust to any apparatus that is given them, but make positive observations. The mode of obtaining the variation of the compass is so simple, that there is no reason, if the trouble is only taken, why any vessel should be misdirected in consequence of the attraction of the iron in the ship. We know when a vessel sails from a port, as she goes down the Channel in the first meridian altitude, the captain, if he only takes the bearing of the sun at the moment when it comes upon the meridian, and enters that in the log, has a standard by which he can then adjust his compasses. The same at night with the stars.—When *any* object is on the meridian, you can get the error of the compass quite sufficient for all steering purposes. The unfortunate thing is this, that persons, after they have taken observations, do not record them. I would suggest that the captains, particularly of iron ships, when they go abroad, should be instructed to enter in the logs from time to time the errors, which they may get instantaneously by reference to the objects on the meridian; and in northern latitudes more especially by reference to the north star at night.

Mr. Evans.—I may supplement the few remarks you have made by calling attention more particularly to these charts. It has been the practice to look upon this subject as a scientific matter, not within the comprehension of ordinary navigators. I do not think that such is the case. Take the case of the variation chart—its use is very great. Independent of its being a philosophical matter, a man having his position in any part of this chart, finding the variation by his compass, and comparing it with the variation, here at once gets his error.

Chairman.—On the part of the Council of this Institution, and those Gentlemen who have listened to Mr. Evans's exposition, I beg to tender him our most sincere thanks for as interesting and valuable a paper as I think I have ever listened to in this Institution. I speak upon this subject as an inexperienced man; but it appears to me that the more the matter is ventilated the better for the commercial marine, and it will probably be a great means of saving human life.

Evening Meeting.

Monday, March 7th, 1859.

Vice-Admiral Sir THOMAS HERBERT, K.C.B., in the Chair.

The Chairman announced that 17 Members had joined the Institution between 22nd February and 7th March.

LIFE MEMBER.

Rattray, James, Vice-Admiral.

ANNUAL SUBSCRIBERS.

Adair, J. W. D. Capt. 5th Fus.
James, Henry, Col. Roy. Eng.
Margary, A. R. Major, late 54th Reg.
Swatman, Wm. Col. 3rd Ben. Eur. Fus.
Baker, W. T. Capt. 85th Lt. Inf.
Hayward, H. B. Lieut. 45th Regt.
Molesworth, M. G. Lieut. Roy. Eng.
Maguire, Rochfort, Capt. R.N.
Yonge, W. L. Capt. Roy. Art.
Yonge, H. J. Lieut. 61st Regt.
Allanway, Wm. Ens. Monmouth Mil.
Railey, Charles, Capt. R.N.
Lane, H. J. B. Capt. Coldstream Gds.
Hogarth, Joseph, Ens. 43rd Lt. Infantry.
Hume, Henry, Lt.-Col. C.B. Gren. Gds.
Armstrong, Sir Wm. Geo. Engineer to the War. Dep. for Rifled Ordnance.

NAMES of MEMBERS who paid INCREASED SUBSCRIPTIONS between 22nd February and 7th March.

Biden, John, Capt. H. A. Coy.
Hamilton, W. D. Major late 13th Lt. Drs.
Briggs, John, General.
Leake, Martin, General.
Stevenson, Wm. Surg. ret. Beng. Army.
Boldero, Lonsdale, Col. unatt.
Armstrong, Sir Wm. Geo. Engineer to the War. Dep. for Rifled Ordnance.
Watson, D. H. Lieut. R.N.
Reddie, James, Esq. Admiralty.

PRESENTS.

LIBRARY.

Books.

Du Feu Grégeois, des Feux de Guerre, et des Origines de la Poudre à Canon. 1 Vol. 8vo. Paris, 1845. Planches, 1 Vol. *Presented by Colonel P. Yorke.*

J. Macintosh, Esq. Macintosh's System of National Defence; or, New Strategies in War. Pamph. 8vo. London, 1858. *Presented by the Author.*

Art Union of London. Report of the Council for the Year 1858. 1 copy; Ditto, with List of Members. 2 copies; Art Union of London Almanack, 1859. 10 copies. *Presented by the Society.*

Royal Geographical Society, Proceedings of. Vol. III. No. 1. *Presented by the Society.*

Lieut.-Col. J. J. Graham. The Art of War. 1 Vol. 8vo. London, 1858. *Presented by the Author.*

Maps—Plans.

156 Old Dutch Charts of the end of 17th Century, and one Illustrated Title-Page. *Presented by the Rev. O. S. Harrison.*

MUSEUM.

Military.

Clothing and Field Equipments of a Rifleman and Soldier of the Line; 1. Knapsack and Set of Necessaries; 2. Light Infantry Chaco complete.

Presented by the Secretary of State for War.

Miscellaneous.

Bell from the Private Chapel of the French Ship "Ville de Paris," weight about 2 cwt., height 1 ft. 6 in., diameter 1 ft. 10 in.; Clock Face from the front of the Poop—the hand was turned by the sentinel at the expiration of each hour—taken in Lord Rodney's action with the French Fleet, 12 April, 1782.

Presented by Captain H. H. Bingham and Commander J. E. Bingham, R.N., on behalf of the family of the late Rev. Richard Bingham, B.C.L.

THE EFFECT OF THE INTRODUCTION OF RIFLED CANNON ON NAVAL ARCHITECTURE.

By Capt. FISHBOURNE, R.N.

I am to show the necessity for a change in the present practice of naval architecture, in order that the country may obtain the full benefit of Sir Wm. Armstrong's admirable invention.

I propose to give, 1st, A sketch of the advantages it affords; more would not be proper. 2nd, A sketch of the practice of naval architecture that it is requisite to change.

The great results obtained from rifle muskets, both as to range and precision, made the adaptation of breech-loading cannon a necessity that could not long remain unsatisfied.

It seems a guarantee for the continuance of our prestige, that no sooner is there a want really felt than genius and skill start up to afford an ample supply.

The principle on which Armstrong's gun is constructed is so correct, and the details of its carriage-slide and missiles so simple and complete, that it will be the work of but a short time to satisfy the most incredulous as to their great value.

The precision of fire attainable by it is alleged by competent authority to be fifty times greater than that obtained with the ordinary service-gun throwing solid shot of equal weight, each at a distance of 1,000 yards; indeed it is six times more accurate at 3,000 yards than the ordinary smooth-bore gun at 1,000 yards.

To arrive at the accuracy of fire, range, and penetration, realised, there have been used, 1st, Elongated shot, by which, while equal momentum has been preserved, a very great reduction of the area of resistance has been effected. 2nd. By the rifle principle, rotatory motion is communicated to the shot, by which, together with the right adjustment of the centre of

gravity, and of the form of its anterior surface, the longer axis during the flight is preserved parallel to the axis of the gun, and great accuracy attained.

Fig. 1.

Hitherto, owing to the extreme difficulty, amounting almost to an impossibility, of casting homogeneous spherical shot, the centre of gravity was never found in the centre of the sphere; hence the shot in their flight were diverted from their proper path, by which great disparities in range and deviation in direction were occasioned.

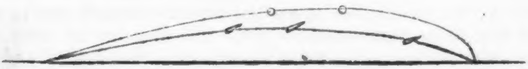
Suppose fig. 1 to represent a spherical shot, *c* its centre, *g* its centre of gravity; when it is projected by the explosion of the charge, owing to the greater amount of surface being to the left of the centre of gravity, the shot will rotate round this centre from left to right: let the arrow represent the resistance of the air to the shot in its trajectory—the direction of which, owing to the rotation described, is opposed to that of the left side of the shot, while that of the right side coincides with it; the result is, that a diminished pressure obtains on the right side, and an increased pressure on the left side; consequently, the shot will be deflected to the right into the line of least resistance;* when the centre of gravity is *below*, the deflection is downwards, by which the range is shortened, and, though the absence of homogeneity is directly a source of great error, in practice it produces indirectly still greater. Thus the captain of the gun, observing that a shot falls either to the right or short, attributing this to misdirection of the gun, or to insufficient elevation, rather than the true cause—that assigned, he gives more elevation, or points his gun to the left of the object; of course under these circumstances, if the centre of gravity of subsequent shot be *not* similarly situated, and the chances are against its being so, it will fall still more wide of the mark.

By using a ball which fills the cylinder of the gun much cause of error is avoided.

The ordinary spherical shot not filling the cylinder, in its motion it strikes one part or the other uncertainly, and becomes proportionably uncertain both in its direction and range.

Everything which contributes to remove the causes of deviation tends to increase range, and increase of range tends to precision of fire; as, under such circumstances, less elevation is required for a given distance, the shot travels nearer the earth, and will strike objects of a moderate height that intervene—as the elongated shot compared with the round shot in fig. 2.

Fig. 2.



Greater safety.—The superior principle upon which this gun is con-

* See Appendix to Col. Lane Fox's Paper on the Improvement of the Rifle, vol. II. p. 489 of this Journal.

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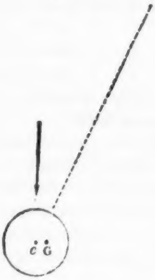

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Greater safety.—The superior principle upon which this gun is con-

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structed is a greater guarantee against its bursting; and it cannot reasonably be doubted but that loading at the breech will be attended with less danger from accidental explosion of charges; also, the danger to men (increased by the introduction of rifles) while loading at the muzzle will be avoided, and the occasional danger from fire left within the gun is disposed of by the use of a moist sponge.

Greater rapidity of fire—by which I mean the delivery of *effective* fire.—I use the expression *effective* advisedly, as a comparison as to the rapidity of firing without aiming at an object has been sometimes absurdly instituted. Armstrong contemplates firing four times in a minute.

The facilities for delivering a rapid fire from this gun are great, because the distance which the cartridge and shot have to travel is much less—because the position of the loader is more advantageous for effecting his object, which, in comparison of muzzle-loading, is enhanced in proportion to the weight of the shot used; and, should an accident occur to the rammer—not uncommon to the long handles of those used for smooth-bore guns—this can be loaded by hand.

The gun has not to be run up each time, nor does it require to be pointed each time, unless the object or battery be in motion; even then the facilities for pointing are greater than in the ordinary guns.

The power of delivering a rapid fire may not with propriety be estimated for a limited period, but rather be connected with the adaptation for comparatively continuous fire.

As the charges are considerably less than half those ordinarily used, and, as the moist sponging and the rush of cool air from the open breech tend to keep the gun cool, the fire could be continued very much longer than from the ordinary guns.

Economy.—In estimating this, owing to its increased efficiency, it would be impossible to set off the cost of gun against gun, but rather against the cost of the number to which, owing to greater range, precision, and power of dispersion, it in effect is equal to.

Convenience.—This hardly expresses the increased value of this gun due to its greatly reduced weight; owing to which it admits of easy transport—field-pieces and guns for battering purposes being much less than half the weight of those ordinarily used.

Great as are the advantages stated, it possesses greater for ships' batteries, for reasons which I purpose giving hereafter, proceding first to give a practical illustration of the comparative advantages before alluded to.

Lieutenant Dahlgren (United States Navy) mentions that at 260 yards each of ten shot fired from a 32-pounder were included in four feet square of the screen aimed at, while of ten shot fired from the same gun at a screen 40 feet long by 20 feet high, and distant 1,300 yards, only three struck: that is, at five times the distance, though the target was increased fifty times, only one-third of the shot fired hit it. One hundred shot fired from Armstrong's gun at a target nine foot square, and distant 1,500 yards, struck nearly every time, knocking it down several times; after which it was fired at, still on the ground, and was hit several times; and yet all this occupied but two and a quarter hours, and the temperature of the gun at the termination was only 150°.

Although this illustration tells very much in favour of the latter gun, such estimates, founded upon mere "hits" of large targets, by no means mark its immense superiority; for, as the value of guns is in proportion to their power of throwing shot into embrasures, of hitting a narrow and definite line for breaching purposes, or of throwing shot into ships' ports, or of hitting them "between wind and water," so must estimates of their comparative value be drawn from the precision with which they strike *small* objects. The additional value of those described for ships of war arises from the fact of their being so much lighter, and from the small amount of their recoil *(practically none)*, owing to which they will not require ships of such great breadth. This involves very great general naval efficiency and economy.

The small external diameter, particularly at the chase, will admit of smaller ports; no inconsiderable advantage should ships' sides be covered with plate-iron.

It is not my purpose to state all the advantages to be derived from this admirable invention; sufficient has been said to show the necessity for its introduction, and that doing so at an early period will cost the country much less. The efficiency of the navy also will be increased in proportion to the promptness with which it is applied, provided its value is not rendered nugatory by an absence of adaptation in the forms of the ships.

The wonderful success described has been obtained by an accuracy of detail that some, who pique themselves upon being practical, I say not how correctly, would, *à priori*, have characterised as theoretic and crochety, but which nevertheless has proved to be eminently practical.

If the practice of naval architecture is to be progressive, if, in fact, we are to elevate it to the rank of a science, which it is now only in part, whatever professional architects may say to the contrary, we must follow out our observations and experiments with similar accuracy of detail.

The present practice, for war purposes, bears the relation to what it ought to be, that the service ordnance does to Armstrong's guns.

Not that ships may be designed that shall sail or steam fifty times faster than at present; but they may be made some indefinitely large quantity more valuable for war purposes—it may be, in some cases, fifty times more so, and at less cost.

It has been said that the introduction of steam and progress of scientific discovery necessarily entailed rapid and extensive changes—say, rather that this progress has found us pursuing an unscientific course. Science moves with measured strides, like "coming events casting their shadows before;" her every step is the subject of law, and none can follow, however distant, but must be so far in harmony with her designs as not to need at any time to have recourse to more rapid or to radical changes. Thus, the lengthening of new ships' bows ought not to have been required, as the long bow should have formed part of the original design, its value having been proved full fifteen years previously; indeed, the longest adopted are still shorter than that which science would dictate.

We condemned a whole fleet of ships; and yet, whatever were their defects of size, for correctness of design, and for adaptation to the purpose for which they were intended, as a whole they are unsurpassed, nay, unequalled by their successors. Let me not be misunderstood. It is

true that the latter were larger and, in the ordinary sense of the term, finer ships; yet, had we adhered to the principles contained in these earlier forms, we should have more efficient ships than we now possess.

Again, when steam-power was introduced the authorities had embarked at a cost of three millions in building another fleet * of ships of great proportionate breadth, and of a general form that was opposed not only to the authority of the best standard treatises on the subject, but to the accumulated experience of ages; nor was it the introduction of steam that opened our eyes to the fact that in building such vessels we were steering vastly wide of the track which science would have dictated—that fact was made patent by the sailing squadrons of 1846 and 1847, which led to the abandonment of the extreme peculiarities of the forms alluded to. No doubt, however, the expensiveness of steam as a motor forced upon reluctant minds the fact, that ships of greater proportionate length than had ever been adopted were more easily driven, whether by sails or steam. Long before that, however, merchant sailing-vessels of this and other countries had yielded abundant proofs to that effect. Why we should not have drawn inspiration from such sources it is difficult to understand.

But, while the discovery that we were far wide of the proper track led to a decided improvement in our practice, it did not lead us to the re-adoption of those sounder principles of design which characterised some of the older models, both French and English.

This is attributable in some respects to the same cause as that which led to the adoption of great proportionate breadth and rising floors, viz. the undue importance attached to great speed, and the misapprehension how that quality might best be obtained. This had the effect, not yet wholly got rid of, of obscuring what one might have supposed to have been very obvious, viz. the fact that it is impossible to exaggerate one quality in a ship without proportionally diminishing one or more others.

It is too much the habit of professional men to assume that laymen cannot understand these things; they, therefore, deliver their opinions *ex cathedra*, and afford us no proof: on the contrary, I profess to be a sailor, and have long acted upon the principle, that, if I could not explain to an intelligent mind or indeed educate an uninstructed one up to a comprehension of any point connected with my profession, the fault was in myself. Now what we require is, that naval architects will cease to obstruct those who are searching for truth, acknowledge—what all are beginning to discover—that there is an amazing amount of ignorance on the subject of naval architecture even amongst those who have studied the subject most, and join us in our search. Enough of time and money has been wasted in experimenting without system, and too often in violation of principles; no plans should be accepted without proofs of their correctness, or without being tested by the application of carefully arranged statistics.

As our information in some respects is only comparative, we may thus inquire what the fact is as respects some of our modern ships of war. If there is an adherence to principle in their designs, we shall be able to trace a consistency throughout, that is, a definite relation in the proportions of one dimension to another, as length to breadth, depth to breadth, and in

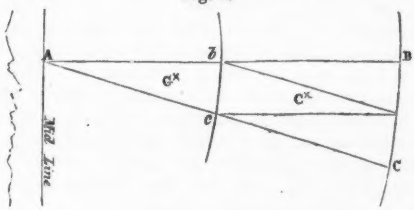
* This will account for the great number of ships of the line which we possess, and which it is proposed should be allowed to rot.

screw vessels between the area of screw and its depth of immersion, and the area of greatest section, or only such a departure as was indispensable, and as did not mar the design.

There are two things which have always been held as ruling the proportion of breadth to be given to vessels of war—a sufficiency to obtain stability and a good platform for guns. The precise quantity necessary has been for some time a vexed question, therefore an opinion from any one cannot be deemed sufficient. Nevertheless, what is not a proper quantity may be arrived at, and much fairly inferred from that.

Ceteris paribus, stability increases as the cube of the breadth, the moment of sail or power that produces inclination not increasing in so rapid a ratio; consequently the larger the ship the less is the proportion of breadth required to produce a sufficient amount of stability.*

Fig. 3.



When a vessel inclines she immerses a prism on one side and emerges an equal one on the other; by the volume of these, and by the distance of their centres of gravity from each other, is a vessel's stability compared with that of another. Suppose fig. 3 to represent one of these prisms for each of two vessels, one double the breadth of the other; from this it will appear that **A** *b c* is only one quarter that of A B C, and G is only half the distance from A that C is, therefore the effect of the larger prism is equal to $4 \times 2 = 8$; in other words the stability of a vessel of double the breadth is eight times that of the smaller; but 8 is the cube of 2.

The following dimensions—

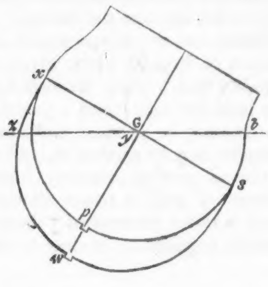
	Length. feet.	Breadth. feet. in.	Ratio of Length to Breadth. feet. in.
Marlborough ..	245	61	4 0
Renown	245	55·6	4 $\frac{23}{55}$
Racoon	200	40	5 0

show that the smaller vessels have the least proportion of breadth, which is the reverse of what adherence to the law above described would require. Nor can it be said that this arose from the necessity for a wider battery in the larger vessel, for the "Racoon" carries guns on her broadside of equal length and calibre with those carried by the "Marlborough."

There is another dimension, viz., the depth, which exercises an important influence on the properties of ships; this, also, has been treated as if there was not a proportion of it to breadth that was more correct than any other.

* By stability here, I mean the power to resist inclination from the pressure of the sails, a quality which conduces under certain circumstances to fast sailing.

Fig. 4.



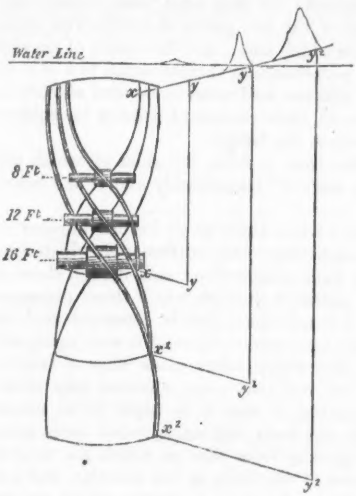
If we suppose Fig. 4 to represent the cross section of a vessel, which may be taken as far as the principle involved is concerned to represent all her sections, and she to be inclined to the angle *x y z*, this will be as if the emerged solid *x y z* were carried over to *y b s*, and the power requisite to effect it will be great as the volume of these solids is great in proportion to the whole volume of the ship. If we suppose the ship's immersed depth to be only from *y* to *p*, then the volume of these solids will be greater in proportion to the volume of the ship than if her depth be increased to *w*; that is, suppose it possible while the vessel is inclined that an increased volume were given between the line *x p s* and *x w s*; the volume of the solids *x y z* and *y b s* not being increased, the effect would be to float the keel up and diminish the stability. This is what takes place when a vessel is made deeper in proportion to her breadth, yet, strange to say, the smaller vessels are those which are chosen to be made deeper, and so their proportionate stabilities are further reduced, though already small from their limited size, and less also, because they have received a less proportion of breadth to length; thus:—

	Mean draught. feet. in.		Half breadth. feet. in.		Difference. feet. in.
Marlborough . .	25 0	to	30 6	=	5 0
Renown	24 0	to	27 6	=	3 6
Racoon	18 5	to	20 0	=	1 7

Now, if the smaller ships have sufficient breadth of beam for stability and for a good battery, then the larger ships must have too much; that they have will further appear from other considerations, for it cannot be said that the "Renown," because of having a deck more than the "Racoon," requires fifteen feet more breadth. Again, in order to obtain satisfactory results with a screw, that is, speed economically, it is necessary that the area of the screw shall bear a certain relation to the area of the greatest section, and that the screw shall be sufficiently immersed to obtain sufficient resistance to its thrust. From the following diagram it will be clear that the greater the diameter of the screw, the greater is the distance it should be immersed to obtain proportionate effect.

Suppose fig. 5 to represent the forces given off by screws supposed proportionate to their diameter, for it would be impossible to apply a large power to a screw of small diameter, then the lines $x\ y$, $x^1\ y^1$, and $x^2\ y^2$ may be taken to represent the direction and force of the thrust from each of 8, 12, and 16-foot screws respectively; from this it is clear that, if the larger screws are not more immersed than the smaller in proportion to their size, that part of their thrust will be lost in throwing up water at y^1 and y^2, instead of propelling the ship; this view of the case is

Fig. 5.



confirmed by experience. This points to another ground of objection to giving great proportionate breadth to depth.

The area of greatest midship section, representing the principal element in resistance, will be the same whether the breadth and depth are—

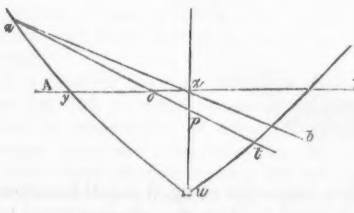
Breadth.		Depth.		
as 44	×	18·2	=	800·8
or 40	×	20·0	=	800

But in the one case the screw could be immersed two feet more, and its effective results proportionally increased. In illustration of this fact it may be stated, that, if the "Diadem" had been two feet deeper, though her displacement were also in that proportion increased, she would have been a faster, as she certainly would have been in every other respect a more efficient, ship.

It has been stated that Sir William Symonds gave great beam to our ships, and that his successors did well to continue it; this is not true in fact, and, nominally, only true of the three-deckers, which, being larger, have equal breadth no doubt, but less in proportion to their length; still I assert that great beam is an unmixed evil.

The ships in question were uneasy, and it was assumed that, owing to the form of the solids immersed and emerged as they rolled, their centres of gravity rose and fell; that this was the sole cause of such motions; and that if their sides near the load water-line had been straight, or equally curved, this motion would not have taken place. This is a mistake, and one that has injuriously affected nearly all our modern ships. The defect may arise from a different cause.

Fig. 6.*



1st. I may explain the effect of the inequalities alluded to:—

Suppose A B to represent the surface of the sea, and *x y u t r* the outlines of a section of a vessel floating upright; for convenience of illustration, suppose the sea line moved on this section from A B to *a b;* this supposes the vessel to have moved round *z* as the centre of her longitudinal axis, which cannot be, as the solids, emerged and

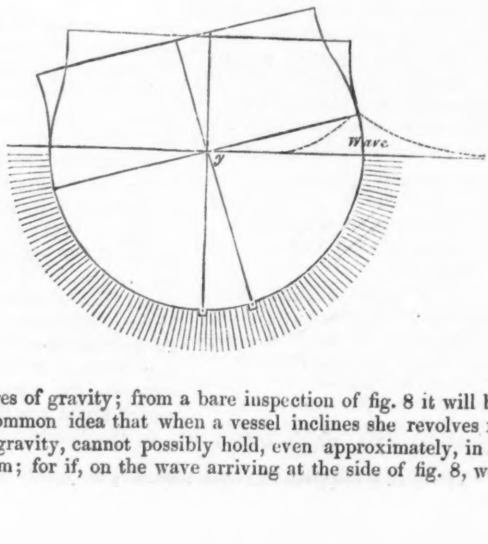
* This figure is exaggerated for better illustrating the point in view.

immersed, must eventually, though not instantly, become equal, which is contrary to the supposition; consequently the ship must rotate round some point, suppose *o*, at the intersection of the two planes that form two equal solids of emersion and immersion, in which case *z* and the centre of gravity equally will have been raised a perpendicular height equal to *z p*. In proportion as ships have this form near the load water-line—and all have it more or less at their extremities—will their centres of gravity be subject to a similar motion—the less, however, the better.

But a similar motion may arise from a form, the sides of which are "either perpendicular or equally curved" immediately above and below the load water-line.

The bottom of a ship is subject when afloat to an infinite number of pressures which act at points perpendicular to the surface with which they are in contact, and sustain her by their joint action; and, though there is ordinarily easy play amongst the particles through which these pressures proceed, yet, when motion round a longitudinal axis is communicated rapidly to such a body, the water resists proportionally as if it were rigid, and the effect is somewhat similar to that which takes place when a body is rolled upon a rigid plane surface; this will take place whatever may be the force which communicates the motion, so that it be rapid in its action. If the force be applied at one side the body will rotate round some point on the other side of the centre of gravity from that on which the force is acting, and more distant as the form of the body is less circular, and less deep than wide. Suppose the inclining forces to be waves, which are the forces we have in most cases, these to be of equal dimensions, and to arrive at the side each of figs. 7 and 8. Suppose *y* and y^1 to be the position of

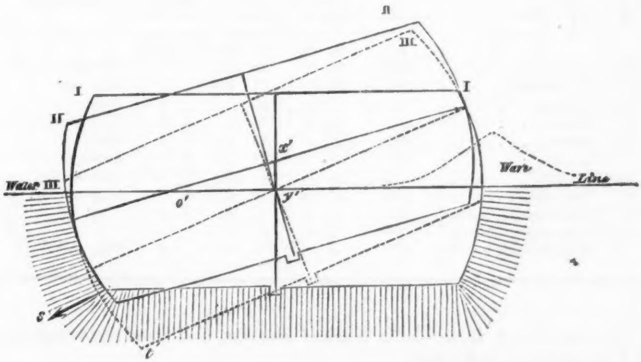
Fig. 7.



their centres of gravity; from a bare inspection of fig. 8 it will be evident that the common idea that when a vessel inclines she revolves round her centre of gravity, cannot possibly hold, even approximately, in vessels of such a form; for if, on the wave arriving at the side of fig. 8, we suppose

her to revolve round y^2, we must suppose a rapid and deeper immersion of one side of her bottom, from s^1 to t^1 against the pressures already on it, when she would assume the position represented by the dotted lines, which

Fig. 8.



is obviously impossible. What takes place is, that the buoyancy added lifts the vessel high in proportion to its amount and the length of lever through which it acts, as compared with the resistance on the opposite side offered to greater immersion—the position the vessel would assume would be rather that of II II than the dotted figure III III.

It is equally obvious that, the wider the vessel and the less the depth in proportion, the greater will be the amount of buoyancy added during the passage of a wave across the centre line of the vessel; the greater the lever to lift her, and the higher will her centre of gravity be raised; the vessel will in reality rotate round some point, say *o*, and her centre of gravity will rise from y' to x; when the wave passes the middle line of the vessel an opposite action will be set up, equally great in proportion to the breadth, but still greater and more rapid from the acceleration caused by the fall of the centre of gravity from the greater height, which will occasion the centre of gravity to rise proportionally higher on the succeeding roll. These motions will be violent and something like that of a wheel going over a stone.

In vessels of the form of fig. 7 there is little of this motion, arising from the fact that the points of pressure are all equidistant from the centre, in consequence of which there never arises a sudden demand for a deeper immersion of any part than that which ordinarily obtains.

The motions alluded to above will take place irrespective of the position of the centre of gravity in the vertical plane; though its position might aggravate the evils described, no arrangement of weights could mitigate the evils of such bad forms as that of fig. 8.

The above is fully confirmed by experience, as may be perceived by

reference to the following table,* which shows that the widest ships with the least proportionate mean draught are the most uneasy—that is, roll quickest and deepest.

1 No. of Guns.	2 Name.	3 Length.	4 Half Breadth.	5 Mean Depth.	Diff. of 4 and 5 Col.	Character.
		ft.	ft. in.	ft. in.	ft. in.	
116	Queen	204	30 0	25 3	4 8	Uneasy.
120	St. Vincent . . .	205	26 9	25 3	1 6	Very easy.
121	Trafalgar . . .	205	27 6	25 3	2 2	Easy.
90	Albion	204	30 0	24 4	5 8	*Very uneasy.*
90	Rodney	205	27 0	24 8	2 4	Easy.
80	Superb	180	28 6	24 7	3 11	Uneasy.
84	Canopus	183	25 6	23 10	1 9	Very easy.
80	Vanguard . . .	180	28 6	24 0	4 6	Very uneasy.
131	Marlborough (Screw)	245	30 6	25 6	5 0	
91	Agamemnon (Screw)	234	27 6	23 6	4 0	
	Birkenhead (Paddle)	210	18 6	17 0	1 6	Very easy.

The old French ships are in marked contrast, and shew the recognition of a principle in designing.

1 No. of Guns.	2 Name.	3 Length.	4 Half Breadth.	5 Mean Depth.	Diff. of 4 and 5 Col.	Character.
		ft. in.	ft. in.	ft. in.	ft. in.	
120	. . . .	209 0	26 9	25 11	0 11	Very easy.
86	. . . .	193 6	25 5	23 9	1 8	—
50	. . . .	173 0	22 5	20 2	2 3	—

The " Albion " rolled through 49° to one side, and somewhat less to the other side, and thirteen times in the same time and under the same circumstances that the " Rodney " rolled only *eight* times and 27° one way, somewhat less the other.

On a different occasion from the above, the " Queen " was observed to roll 20° and 7° and *seven* times in the same time and under the same circumstances that the " St. Vincent " rolled only *five* times and 13° and 5°; usually the " St. Vincent " was only shutting her first lower deck ports when the " Queen " had shut all hers and was commencing to shut her skuttles, which were 18 inches to 24 inches higher than her ports.

The " Queen " has also been observed to roll four times while the " Trafalgar " rolled but once.

Nor can these motions be said to have been due to the inequalities of the solids near the load water-lines, as has been asserted, for the

* *Limited as this table is, it shews the value of statistics,* which are dangerous only in ignorant hands. The contrast drawn above is between sailing ships, simply so, and screw vessels; yet, without controversy, the latter kind should be proportionably deeper.

"Agamemnon," "Hecate," and the "Queen," very nearly so, have their sides perpendicular at that part; indeed, the "Queen" was originally laid down as a "Trafalgar."

If, on the supposition that moving the centre of gravity would mitigate the evil of quick rolling, weights were raised in the "Queen," Albion," or "Superb," as a consequence they would roll deeper, but that fault is already too great; and if weights were lowered quicker rolling would ensue, but this is already too quick.

It must be observed also, contrary to what might have been expected from considering the effect of weights alone, notwithstanding their third deck, which, with its guns, must have amounted to 350 tons, situated say 25 feet above the centre of gravity, the "Queen" and "St. Vincent" were easier, and rolled less deep than vessels of their own type and nearly similar dimensions, viz. the "Albion" and "Rodney" respectively, principally because of their greater immersion, the "Queen" partly because of her fuller body below. This view is endorsed by the reports of their Captains. Captain Lockyer wrote: "'Albion' rolls quicker perhaps for want of ballast, and her rolling has *increased* since the ballast and shot have been removed, and the ship *lighter from want of water and provisions.*" And Captain Corry wrote of the "Superb:" "her rolling is quick, and in proportion to 'Canopus' as 3 to 2, which in light airs, with any swell whatever, renders her very unsteady, and makes it *difficult to take accurate aim with her guns.*"

More recently the "Agamemnon," when she had the Atlantic cable on board, with a swell abeam, and very little wind, rolled 20° to starboard, and 12 to port in 9·4 seconds. It must be added, that this was stated to have been due to the fact of the cable having been stowed too low; a sufficient contradiction to this however is, that the obvious consequence of raising the weight would have been to have increased the extent of the roll, just in proportion as it reduced the rapidity; on the subsequent cruise, but during bad weather, the vessel having been lightened 5 inches, and having had 200 tons of cable placed on the upper deck, lurched to upwards of 40°, and completed her roll in 10·3 seconds. The American frigate "Niagara," on the first occasion, was said "scarcely to roll at all," while the "Agamemnon" was rolling both deeper and faster, and yet she had the greater portion of her moiety of the cable stowed very high; consequently, if the effects described were due to the position of the weight alone, she would have rolled deeper but not so fast. This ship, however, as she discharged the cable rolled more, and considerably by the time she arrived near Newfoundland, when she had discharged the greater part of the cable. Admitting some small portion of the difference between the rolling motions of these two ships to have been due to the difference in their dimensions, yet the principal cause was the large mean breadth of the "Agamemnon," and the comparatively small mean breadth of the "Niagara," as compared with their respective draughts of water, which in the first cruise was equal; the difference of mean breadth being due to their difference of form. If dimensions necessarily make a vessel easier, it may be asked why the "Albion" was so much less so than the "Canopus." The owner of a yacht, and one of the best informed on the subject that I have met, says, "The rolling of my vessel has been strikingly

diminished by lengthening her by the bow 8 feet," which he justly observed must have been in a great measure because her mean breadth was reduced.

It cannot be, as has been said, that the uneasiness of H.M.S. Agamemnon was due to the abstract fact of her being deep, for it is no uncommon thing for merchant ships to be much more so; thus, for instance, a ship of Mr. Green's brought a heavy cargo from Calcutta not long since, and was very easy.

The following dimensions will put this in a clearer light :—

	Length between Perpendiculars.	Half-breadth.		Mean Draught.	
	feet.	ft.	in.	ft.	in.
H.M.S. Agamemnon . .	234	27	6	26	0
Mr. Green's Agamemnon .	244	18	0	19	6
White Star	285	22	6	24	$4\frac{1}{2}$

That is, the merchant vessels "Agamemnon" and "White Star" were proportionally deeper, the first by 3 feet, the second by 3 feet 4, than the man-of-war, which was said to have been under extraordinary circumstances.*

Easiness is so important, that its value should be further illustrated and enforced.

It is stated by Sir Howard Douglas that a second may elapse between the time of pulling the trigger and the time the shot leaves the muzzle of the gun. The arcs of roll of the "Queen" and "St. Vincent" being respectively 3° and $1\frac{1}{2}$° in a second, we have but to suppose equally expert gunners, each to aim at the water line of the other, and each to fire with a rising motion, the ships being 30 feet high and 400 yards apart, and the second alluded to to elapse, the result would be, assuming that there is no other cause of deviation, that the "Queen's" fire would pass over the hull of the "St. Vincent," while every shot of the "St. Vincent" would hit the hull of the "Queen," and yet the "Albion," "Superb," and "Vanguard," rolled three times as fast as the "Queen;" how then could it be expected otherwise than that sister ships to these, as the "Colossus," "Exmouth," and others, should be otherwise than failures.

There is no reason to doubt but that the motions of the "Marlborough,"

* It has been objected that in a pamphlet which I printed last year I understated the draught of water of the Agamemnon, and to that extent undervalued her as compared with the "Napoleon;" this implies that the defects of the former were confined to deficient draught, and that those who objected to my view would have been content had hers been equal to that of the "Napoleon." Now I, on the contrary, contend that her form also is defective in principle, just where the French have borrowed from us, viz., in giving undue breadth; and while, as I believe, she is superior to the Agamemnon, her breadth is still too great by several feet for her depth.

I was contending for a principle, and took the most correct information at my disposal; the incorrectness of this however, even if it had been greater, would not have affected the *principle*, and in the case in point the only thing that was grounded on the fact was the propriety of inquiry before any ships similar should be built, a course not without value whatever the facts may have been.

I could have no wish to misrepresent, inasmuch as the fact, whatever it may be, "cuts both ways;" thus in the same pamphlet I argued that it was not an undue weight of cable that caused her to roll so deep and so rapidly: this argument gains considerable force by the admission that she was only 2 feet or 2 feet 6 inches more than her proper draught, instead of 4 feet, more or less a few inches.

though less than those just named, would be faster than those of such ships as the " St. Vincent " or " Trafalgar," as from the table the difference between her half-breadth and her mean draught is as 5 to 1·6, and 2·2 respectively.

As the deviation increases with the range, it were absurd to expect efficiency from ships that are so uneasy under not unusual conditions of weather; and if unfitted for smooth-bore guns, how much more unsuited to rifle guns, when, in addition to their great range, their shot take longer before they leave the gun.

The following is a more pointed illustration of the necessity for steady platforms. The "Hecate" and "Antelope" were anchored off the coast of Africa under very similar conditions; that is to say, they had about an equal proportion of provisions and water, &c. on board; the former was rolling 11° each way and eight times in a minute—her commander states that her guns could not have been cast adrift and worked without danger.

He visited the "Antelope" officially, and found she was rolling but 5° each way, and about four times in a minute; her guns were cast adrift, exercised, and satisfactorily pointed at a target. The commanders of both vessels agreed that the "Antelope" could have destroyed the "Hecate" with ease, as the latter at a moderate distance could not have hit the former much oftener perhaps than once in fifty times.

In this case we have a vessel carrying only three guns, admitted to be superior to one a sixth larger, and carrying six guns.

It is evident that had the "Hecate" had 100 guns, and had rolled with equal rapidity, supposing only that the "Antelope" should have, as in the case in question she had, greater speed, her 100 guns would not have saved her from the fate predicted of the 6-gun "Hecate;" and if this case can occur with smooth-bore and comparatively short-range guns, how much more certainly would it do so were the "Antelope's" guns accurate and long-ranging rifles.

Rapid as was the motion of the "Hecate," it was less than that of H.M.S. "Agamemnon" under favourable circumstances of weather, and only one-fifth that of the "Albion;" still it was at the rate of 3° in a second.

The form of the "Hecate" and "Antelope" near the load-waterline was similar, so far as having equally vertical sides; consequently, the difference in their motions could not have been due to any inequality there.

I stated in a pamphlet last year that the "Diadem" would roll considerably; it is now reported that she and the "Cæsar," 90, were lying at Greytown together, and that the former rolled twenty-five times, while the latter rolled only fifteen times. If these ships were under equal conditions as to the swell, and equal as to the proportion of coals, water, and provisions they had on board, then are we receding in our practice of shipbuilding, as the "Cæsar" is a much older ship, and a much shorter ship; whatever was the cause of the difference, it should be inquired into, and if possible removed, if not avoided, in any future ship.

In a paper of this sort, it were impossible to do more than clearly recapitulate the principles already enunciated.

The depth of water in which any projected ship is to be navigated should be taken as the limiting principle of the design; from that the

immersed depth should be determined, and the vessel designed on that as a basis, and upon definite principles.

If a maximum fitness as a floating battery or effective sea-going ship, there must be a definite ratio preserved between the breadth and the mean immersed depth. If the horse-power is to be kept within satisfactory limits and a sufficient immersion obtained for an effective screw, the half-breadth should not exceed the mean immersed depth, and the centre of gravity should be kept proportionably low; if a maximum result as to efficiency and economy, so far as form will effect it, a fine bow and suitable midship section should be added—slightly convex at the load-water-line is the best form.

One or two important points bearing rather upon the practice than the principles of naval architecture that should be adverted to are—

1st. The excessively destructive nature of Armstrong's shells, the certainty of bursting them, and at pleasure, and the very much greater degree of accuracy with which they can be thrown, warrant the conclusion that it would be a useless expenditure of men and guns to crowd so many as is now done in ships of the line, since small but suitable ships mounting Armstrong's guns could destroy them without much risk to themselves, if the larger vessels mount only smooth-bore guns and without undue risk if they mount rifle guns. Lofty ships will also be more open to objection as rifle guns are introduced.

The deviation of rifled shot from the vertical plane is so small that, from a steady platform, throwing a shot within the breadth of a vessel of the smallest dimensions, even at 3,000 yards, is a matter of certainty; consequently, the only hope of escape from such would be by avoiding to build ships high. The difference arising from the use of rifles compared with smooth-bore guns may be seen from a comparison of the form of their respective trajectories, which are approximately as

Fig. 9.

On the assumption that these represent approximately the trajectories of shot from the respective kinds of ordnance referred to, it appears that unless the round shot falls within very narrow limits—that of the short line x, fig. 9—it does not take effect, while the rifle admits of considerable error in distance, equal to the line y, fig. 9. The great importance of this difference in ship practice can only be realised by considering, first, that the round shot is subject to much greater error in range than is the oblong shot; and, secondly, the fact that, ships being generally in motion, there is always more or less of uncertainty in the distance of the objects fired at.

No steam fleet can be complete in its equipments without its fleet of colliers, the speed of which will generally regulate that of the steamers, otherwise they will require armed ships to convoy them. The most appropriate use of many of our old sailing vessels would be that of making them colliers, rather than selling them, or allowing them to rot. Give

them Armstrong's guns on their main decks, and small auxiliary power to use in calms, they would double the effectiveness of the steamships by the supplies of power they would carry, and would themselves form no inconsiderable additional force. From their greater steadiness, and the destructive character of Armstrong's shells, they would handle a "Grande Bretagne" or "Duke of Wellington" very severely before they could close to such a limited distance that the number of guns in the latter should overbear the greater precision of the former. The number and size of colliers must be proportional to the aggregate horse-power of the steam-fleet, which shows the necessity of building vessels that will realise the necessary speed with the least amount of horse-power; not directly on the score of economy, though that would be no inconsiderable advantage, but for purposes of efficiency.* From an absence of proper adaptation, the "Diadem," of 32 guns, with 800 horse power, realises little more speed than the "Renown," of 91 guns, with only a similar amount of horse-power, and doubtless not consuming more coal, though the area of their respective midship sections are as about 10 to 13.

Yet, with or without the addition of the auxiliary force above alluded to, we may affirm that till our naval history, which now details almost uninterrupted triumphs, is substituted by records of disasters, England will not have anything to fear from a single-handed foe.† From a combination in the early stages of a war she might apprehend injury; then only because of wanting men, or because the rear of her fleets might not be open to obtain supplies of coals. Were Armstrong's guns and fittings adapted throughout our Service, it would afford us a solution of this our greatest difficulty. His 70-pounders can be worked by five men as easily as the smooth-bore 68-pounders by seventeen; while in certain conditions of the sea the former could be used with effect, though the latter could not be "cast adrift" with safety. Nor is it a small advantage, physically and morally, that these five men are relieved from the labour and distraction of running the guns in and out. Even courage would evaporate with the intense exertion of working large guns, and carefulness in pointing would be at an end. In fact, the weight of men and guns moved in this operation every round shifts the centre of gravity of the ship from 12 to 18 inches, which generates oscillations in the smoothest water fatal to that accuracy which is of increasing importance.

Armstrong's gun, on the other hand, working on a pivot—the recoil being provided for by a beautiful arrangement—the hustle and bustle of tackles and the exhaustion alluded to is provided against.

* It has been well said by an American naval officer that *great* steam-power is of most value for running away. It certainly will not in action prove of the high value which has been given it, nor will the result justify the great sacrifices which have been made to obtain it. When such ships have used much of their coals, they roll very much, which will in action place them very much in the power of auxiliary-powered ships, if not also in those of sailing ships. If large powered steamships go into action they must come down to the terms of their opponents; and if the latter are also to make good use of their time, the speed of the former may not suffice to take them out of action in time.

† We possess a very much larger number of sailing ships than any other power; and the necessity for an auxiliary force, such as I have described, shows that these vessels should all be counted as part of our effective force, provided only that men can be obtained for them.

Again, the demoralisation which was found during the war to arise from wounds and death occurring on crowded decks will be entirely avoided by small crews.

Effective sea-going ships with iron-plated sides can be obtained only by building them for the purpose, and then narrow and deep. Plated ships we shall come to, though it might be that neither the plates nor the ships' frames should resist rifle 70-pounders, or heavier shot, at comparatively short distances; for at such distances plating becomes of much less value, as the accuracy attainable with Armstrong's guns will admit of the shot and shell being put through the portholes—the proper way, indeed, to assail, as the enemy's guns and men are collected there; but it may be that less heavy plating than that proposed may be used with advantage.

Such adaptations as the "Gemappes" can be but bad make-shifts, justifiable only because of having ships that ought to be utilized; to build anything like her or still less like any of our wide ships would be unpardonable, as this were to throw away the principal advantages offered by this gun.

The crew that would suffice for thirty-six of Armstrong's guns would be wholly inadequate for the large masts of such vessels as the "Gemappes;" or suppose ninety of his 70-pounders placed in the "Renown" in lieu of her hollow-shot 68-pounders, it would be absurd to draw any comparison between the two armaments, the former is so superior in range, in accuracy, in lightness, in the certainty of the action of the shells, in the security in a seaway, in the limited amount of powder they require, in dispensing with tackles, and, notwithstanding the assertions to the contrary, in the destructive character of his shells. Other shells, owing to the circumstance of their centre of gravity being on one side, are subject to great deviation, and they are uncertain in bursting; many fell into the ditch at Sevastopol unexploded; Armstrong's, on the contrary, always explode. And, though the hole made by their entrance is very small, this is a cause of their greater efficacy, making a small hole, and entering the wood rapidly, the hole closes after them, so that when the bursting powder, of which there is a larger quantity, explodes, its effect is greatly intensified in consequence of its being so confined, vastly more than takes place where the hole is larger, as part of the explosive force passes away through it. Consequently, were the "Renown" thus armed, she would have a far more effective armament; and, were it not for her large masts and sails, might have her crew applied to the manning of two other 90-gun ships; reduce her breadth, and her masts and engines may be reduced in the same proportion. This also would be altering in a direction to obtain a steady platform, and, great as these advantages would be in effectiveness, and in economy, they would be nothing in comparison of the priceless value of the men made available for manning other ships.

I fully believe that a saving on one such ship, if it were deemed expedient to place so many as 90 of Armstrong's guns in one vessel, including first cost and current expense of men and ship for one year only, would amount to the greater part of £100,000.

It may not be deemed advisable to reduce the crews to the extent implied in the foregoing; nor could it be so done with existing ships, though

their armaments were changed, yet it cannot be that such large crews shall be retained only because of large masts and sails; ships must be built that will not require such.

At no distant day Armstrong will suggest modifications in existing ordnance and their carriages as will better adapt them to the object for which they were intended, and admit of a reduction of the number of men required for working them; so on all accounts ships that require large masts and sails will fall into disuetude.

Cutting the "Gemappes" down and covering her sides with iron plate suggests a doubt of the propriety of building ships of the line, even though they were suited to undergo a similar transformation. It it very much to be doubted that this ship will prove a good sea-going ship, and yet, owing to her small breadth as compared with her immersed depth, and the large amount of ballast she carries, she will be much more likely to yield a satisfactory result than any in our service.

I had hoped to have given some proofs drawn from recent trials; if any have been tried, they are kept from us, the principal effect of which is to keep naval officers ignorant, and naval architecture unimproved.

Our dockyards having been for a long series of years the largest ship-building establishments in the world, and vessels of the greatest diversity of form having been built in them, we ought to possess an amount of experience, limited by no personal pecuniary considerations, as all experiments have been at the public expense, and a mass of facts that, if tabulated and used with ordinary intelligence, would have prevented the necessity for our copying the French floating batteries, as we are said to have done, at a cost of well nigh half a million, and have afforded a guarantee against other eminent failures that have occurred from time to time.

The subject is vastly too important to be treated in the flippant way it has been, even by professional men,—another illustration that they get into ruts which those outside are the first to discover.

I have stated my opinions decidedly, because I feel assured that the whole subject of naval architecture requires reconsideration, and that our ships should be designed on some more definite and satisfactory principle than they are; and because I feel strongly that the nation which fully adopts Armstrong's gun, and all the measures necessary for developing its great powers, will be benefited to an extent that no numerical advantage of ships and guns similar to those now in use can counterbalance.

In this case the invention will prove vastly more advantageous to us, as it will enable us, while increasing the efficiency of the *materiel*, to place the *personnel* of the navy on a sufficient and entirely satisfactory footing, without further taxing the springs of industry.

Sir William Armstrong, Kt., C.B.—In consequence of the injunctions at present imposed to secrecy, there is but little I can say on the subject of rifled guns, but there are a few points connected with the trajectory of the projectiles which I may observe upon.

In a vacuum the trajectory would be the same whether the projectile were elongated or spherical, so long as the angle of elevation and the

initial velocity were constant; but the presence of a resisting atmosphere makes this remarkable difference, that while it greatly shortens the range of the round shot it actually prolongs that of the elongated projectile, provided the angle of elevation do not exceed a certain limit, which in my experiments I have found to be about 6°. This appears at first very paradoxical, but it may be easily explained. The elongated shot, if properly formed and having a sufficient rotation, retains the same inclination to the horizontal plane throughout its flight, and consequently acquires a continually increasing obliquity to the curve of its flight. Now the effect of this obliquity is, that the projectile is in a measure sustained upon the air, just as a kite is supported by the current of air meeting the inclined surface, and the result is that its descent is retarded so that it has time to reach to a greater distance.

With regard to lateral deflection, if from any cause the axis of the projectile should become inclined to the vertical plane, the resistance of the air operating on the inclined surface will press it to the right or to the left, according to the direction of such inclination.

The causes of the axis thus deviating from the vertical plane are somewhat complex, but are due to the manner in which the atmospheric resistance operates upon the under surface of the projectile in relation to the upper part, and upon the curved or conical end in relation to the cylindrical part. As a general observation, I may state that a rotation from left to right (looking on the upper side) will produce a deflection to the right, but the more the form of the projectile approaches that of a simple flat-ended cylinder the less will be the amount of that deflection. In fact, when a rounded or conical end is altogether absent, the deflection will even be reversed or take place to the left. Another cause of deflection exists in that class of projectiles which have projections upon them for the purpose of taking hold of the rifled grooves. Such projections act as fanners upon the air, but not with equal effect upon both sides of the projectile, inasmuch as the air is condensed on the one side and rarified on the other. It becomes an important point therefore to determine at what part of the projectile such projections should be placed so as to produce the least possible disturbance of equilibrium affecting the axis.

The deflections of which I have been speaking are of a permanent character, but it is the variable deflections which are the most difficult to deal with. I cannot here enter upon this part of the subject further than by stating that want of fit in the gun is the principal cause which produces irregular deflections in an elongated rifled projectile.

With regard to the application of rifled guns in ships of war, I entirely concur with Captain Fishbourne in what he has stated as to the importance of a steady platform. I think also the number of guns in a ship should be very much less than at present; but that the power of each should be as great as possible. Numerous guns involve crowds of men, and produce so much smoke as to render it impossible to aim. But, above all things, it is important in introducing these guns that the training of the seamen in the use of them should be proportionate to the more refined character of the weapon; and I earnestly hope that the Government will take effectual means to ensure the adoption of a proper system of instruction.

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